Horizon 2020 Societal challenge 5: Climate action, environment, resource efficiency and raw materials

BINGO

Bringing INnovation to onGOing water management –

a better future under climate change

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This report is an update of Deliverable 4.1 submitted on 1st of April of 2016

Evidence of accomplishment
Report

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

ABLGVFX	Associação de Beneficiários da Lezíria Grande de Vila Franca de Xira (Association of Beneficiaries of Lezíria Grande de Vila Franca de Xira)
AMB	Àrea Metropolitana de Barcelona (Metropolitant Barcelona Area)
APA	Agência Portuguesa do Ambiente (Portuguese Environment Agency – National Water Authority)
ARBVS	Associação de Regantes e Beneficiários do vale do Sorraia (Association of Irrigators and Beneficiaries of Sorraia Valley)
ARH	Administração da Região Hidrográfica (River Basin District Administration or Hydrographic Region Administration)
ARH_TO	Administração da Região Hidrográfica do Tejo e Oeste (River Basins District Administration of Tagus and West)
BINGO	Bringing INnovation to onGOing water management
CADC	Comissão para a Aplicação e o Desenvolvimento da Convenção sobre Cooperação para a Proteção e o Aproveitamento Sustentável das Águas das Bacias Hidrográficas Luso-Espanholas Convenção de Albufeira (Commission for the Implementation and Development of the Convention on Cooperation for the Protection and Sustainable Use of Luso-Spanish Water Watersheds)
CAP	Common Agricultural Policy
CAP	Confederação dos Agricultores de Portugal (Confederation of Agricultures of Portugal)
CC	Climate change
CGA	Comissão de Gestão de Albufeiras (Reservoirs Management Commission)
CIM	Comunidade Intermunicipal da Lezíria do Tejo (Intermunicipal Community of Lezíria do Tejo)
CoP	Community of Practice
COTR	Centro Operativo e de Tecnologia de Regadio (Operatve Center and of Irrigation Technology)
CNA	Conselho Nacional da Água (National Water Council)
CRH	Conselho de Região Hidrográfica do Tejo (River Basin District Council or Hydrographic Region Council of Tagus)
CSO	Combined Sewer Overflows
CY	Cyprus
DE	Germany
DGADR	Direção-Geral de Agricultura e Desenvolvimento Rural (Directorate General for Agriculture and Rural Development)

DMP	Drainage Master Plan
DRAOT	Direcção Regional do Ambiente e Ordenamento do Território (Regional Directorate for Environment and Spatial Planning)
DRAPLVT	Direcção Regional de Agricultura e Pescas de Lisboa e Vale do Tejo (Regional Directorate for Agriculture and Fishery of Lisbon and Tagus River Valley)
EAFRD	European Agricultural Fund for Rural Development
EDP	Eletricidade de Portugal (Electricity of Portugal)
EEC	European Economic Community
EPAL	Empresa Portuguesa das Águas Livres – Grupo Águas de Portugal (EPAL – Public Water Supply Company to Lisbon and all the right margin of lower Tagus river)
ERSAR	Entidade Reguladora dos Serviços de Água e Resíduos (Regulatory Authority on Water and Waste Services)
EU	European Union
FMR	Framework for Managing the Risk
GPP	Gabinete de Planeamento, Políticas e Administração Geral (Office of Planning, Policy and General Administration)
INE	Instituto Nacional de Estadística (Spanish National Institute of Statistics)
IPMA, IP	Instituto Português do Mar e da Atmosfera (Portuguese Institute for Sea and Atmosphere, I. P.)
LGVFX	Lezíria Grande de Vila Franca de Xira
LVT	Lezíria do Vale do Tejo
MAFDR	Ministério da Agricultura, Florestas e Desenvolvimento Rural (Ministry of Agriculture, Forestry and Rural Development)
MANRE	Ministry of Agriculture, Natural Resources and Environment (Cyprus)
MAOTDR	Ministry of Environment, Regional Planning and Regional Development (Ministério do Ambiente, do Ordenamento do Território e do Desenvolvimento Regional)
MAP	Mean Annual Precipitation
NGO	Non-Governmental Organization
NL	Netherlands
NO	Norway
NVE	National Hydrological Directorate
PAM	Plan de Acción Municipal (Municipal Action Plan)
PDR	Plano de Desenvolvimento Rural (RDP - Rural Development Plan)
PESTLE	Political, Economic, Social, Technological, Legal and Environmental

PIP	Public Irrigation Perimeter
PT	Portugal
PWS	Public Water Supply
RD	Real Decreto (Spanish Royal Decree)
RDP	Rural Development Programme
REN	Redes Energéticas Nacionais (National Energy Networks)
RMP	Risk Management Process
RRM	Risk Reduction Measures
RS	Research Site
SP	Spain
UNEP	United Nations Environment Programme
WA	Wupper Association
WFD	Water Framework Directive
WTP	Water Treatment Plant
WP	Work package
WR	Water Resources
WWTP	Waste Water Treatment Plant

1 INTRODUCTION

1.1. Background

The BINGO project proposes a "Framework for Managing the Risk" (FMR), which can be seen as a central theme connecting the climate scenarios with the climate change (CC) adaptation strategies set up. WATER is the central resource in BINGO. Climate change is the driving force for adaptation. Deviations from average weather patterns can lead to two main types of extreme conditions scenarios: dry periods or droughts, and inundations (by river or groundwater flooding, by extreme rainfall and sewage overload, or by marine origin as storm surges, spring tides and sea level rise), with different time scales of events (hours to days or weeks, for inundations; months to years, for drought) and different types of adaptation strategies.

Many entities, organizations and scientific studies have already identified and listed numerous possible climate change adaptation measures, related to water resources management and adaptation in various economic sectors. In order to make a difference, the BINGO project incorporates already known adaptation measures, as well as new ones designed in BINGO, into CC risk-based validated adaptation strategies for six Research Sites (RS), and then will extrapolate the results achieved at those RS level to European policies.

The approach proposed in BINGO is based on ISO 31000:2009 (Figure 1.1), consisting of a general Framework for Managing Risk (FMR) that supports and frames the specific categories of risk to be managed through a "Risk Management Process" (RMP).

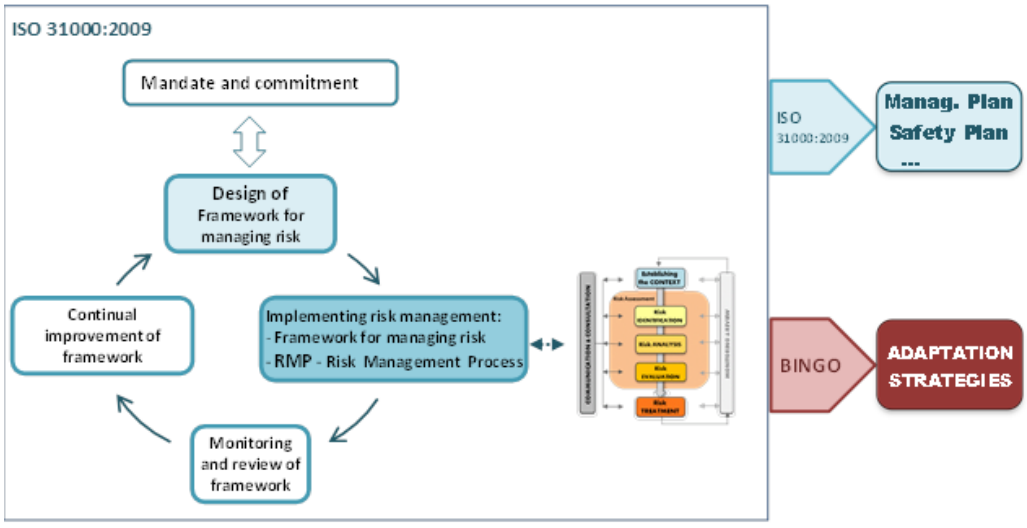


Figure 1.1: Relationships between the FMR and RMP (Rocha, 2016)

The Framework for Managing the Risk (FMR) expresses the risk objectives and policy of an Entity (Organization). Aiming to achieve its objectives, an Organization can perform a Risk Management Process (RMP) covering all possible risks which compromise the accomplishment of its objectives or, alternatively, can isolate certain particular types of risks or sectors, and perform a more targeted RMP covering those specific cases (Rocha, 2016).

BINGO is not suitable for a full Risk Management Framework implementation. Methodologies, tools, strategies and policies are envisaged outputs of BINGO, not compatible with a complete implementation of an ISO RMP, structured and oriented for an organization. In fact, when applying such a framework to an organization, the outputs are risk management plans or safety plans or other sets of activities. The output of BINGO will be mainly CC adaptation strategies (Figure 1.1).

1.2. RMP and links with WP4 and other BINGO WP

A Risk Management Process includes several key steps, each of them with a significant purpose, that, when undertaken in sequence, enable continual improvement in decision-making (Figure 1.2):

- Establishment of the RMP context;
- Risk assessment, consisting of:
    - risk identification;
    - risk analysis and
    - risk evaluation.
- Risk treatment;
- Communication and consultation;
- Monitoring and review.

The objective of **WP4** is to perform the first two steps of RMP: i) to establish the context and ii) to perform risk assessment (including risk identification, analysis and evaluation) at the BINGO RS. The first step was carried out throughout Task 4.1 and the second will be developed in Task 4.2 (Risk Identification) and Task 4.3 (Risk Analysis and Risk Evaluation). The latter will provide decision on the risks that need treatment (**WP5**), which will be based on the comparison of results from risk analysis with previously set criteria.

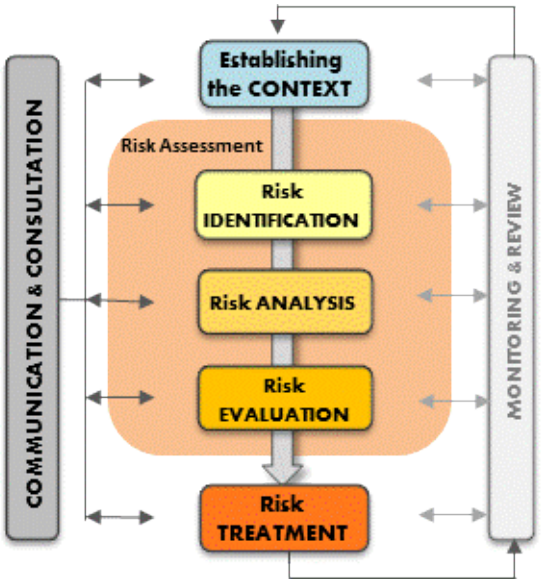


Figure 1.2: Steps of the Risk Management Process (ISO 31000:2009)

In what concerns the RMP links to others BINGO WP (Figure 1.3), based on the climate change scenarios defined in **WP2** and on the predictions of their effects on the water cycle (water quantity and quality, inundation areas and drought spatial coverage) achieved on **WP3**, **WP4** is focused on the impacts of these effects on water-related human activities, namely: water resources management, water supply, agriculture, tourism and urban activities.

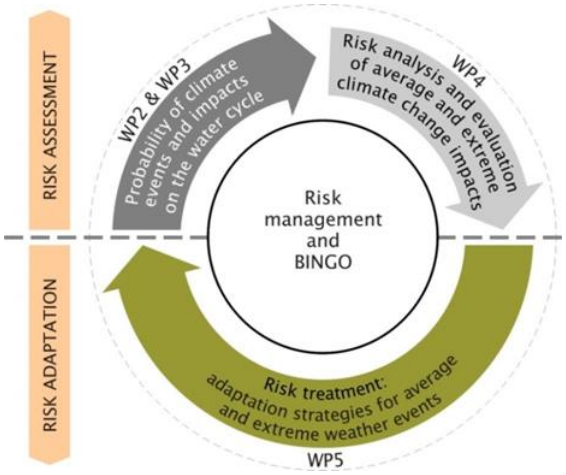


Figure 1.3: RMP in relation to BINGO Work packages (source: Figure 5 of BINGO proposal)

Once the risks are identified, analysed and evaluated it is possible to prioritize them in order to support decision making in adaptation strategies definition. **WP5** will produce and analyse options for risk validated adaptation strategies to cope with climate change. To support these processes, **WP6** (communication and consultation) will act as a cross-cutting issue throughout the entire project.

1.3. BINGO common language

Different scientific disciplines have distinct risk definition concepts. A frequent difference is observed between hydrologists, who consider risk as the probability of occurrence of an extreme event, and those that manage the consequences of the events. The concept of risk differs significantly among areas of focus and, therefore, the methodologies to address it can also change.

Whenever possible, the risk definitions from ISO Guide 73:2009 are used, aiming to achieve a BINGO project risk common language. The clarification of some terms was agreed among partners. Complementary terms were defined when considered necessary. This information is included into the BINGO GLOSSARY presented in Annex I. For an overview here, the most relevant definitions are presented in Table 1.1

Note that risk constitutes the first definition to carry out, and within BINGO it was defined as a combination of the consequences (damage) of a hazardous event (including changes in circumstances), and the associated likelihood of occurrence (probability). The level and magnitude of the consequences will depend on the characteristics of the hazardous event as well on the vulnerability of the system, namely on (Figure 1.4):

- Exposure, which is the extent to which a system is subject to an event and basically depends on the presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social, cultural assets in places that could be adversely affected (IPCC, 2013);
- Susceptibility which is the degree to which the system is affected, depending on the own intrinsic characteristics of its elements (for instance, the social and economic context of the exposed community, the physical and environmental characteristics of the impacted system, etc.);
- Resilience which is the adaptive capacity of the system in a complex and changing environment, a factor which decreases the potential damaging effects, and which must therefore also be considered when assessing the risk (ISO Guide 73:2009).

Table 1.1: Most relevant definitions within BINGO based on ISO Guide 73:2009

Expression	Definition
Risk Owner	A risk owner is the organization that has been given the authority to manage a particular risk and is accountable for doing so.
End-user	An organization that develops activities subjected to the Risk Management Process. In BINGO, the end-user is the Risk Owner.
Stakeholder	Organization that can affect, be affected by, or perceive to be affected by a decision or activity developed by an end-user.
Hazard	Source of potential harm. A hazard can be a risk source (ISO Guide 73:2009). A dangerous phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (MRC-CCAI, 2013).
Event	Occurrence or change of a particular set of circumstances. An event can be one or more occurrences, can have several causes, can consist of something not happening. An event can be referred to as an “accident” or “incident”. The latter is an event without consequences (ISO Guide 73:2009).
Risk source	Element which alone or in combination has the intrinsic potential to give rise to risk. A risk source can be tangible or intangible. The risk source is where a potentially hazardous event begins (ISO Guide 73:2009).
Consequence	Considered as the extent of harm, which can be expected under certain conditions of exposure, susceptibilities and resilience. The indicators for this component can be separated in two categories; the first one gives details on the general characteristics of the hazardous event and the second one covers the vulnerability of the different elements at risk.
Vulnerability	Vulnerability refers to the propensity of exposed elements (such as human beings, their livelihoods and assets) to suffer adverse effects when impacted by hazard events. Vulnerability is related to predisposition or capacities that favour, either adversely or beneficially, the adverse effects on the exposed elements. Vulnerability refers to exposure, susceptibility and resilience.
Exposure	Extent to which a system is subject to an event. Refers to the inventory (and values) of elements that are present in areas in which hazardous events (floods or other) may occur and can be adversely affected (potentially damaged or disrupted) by those events. These values depend on the presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social, cultural assets in places that could be adversely affected (IPCC, 2013)
Susceptibility	Susceptibility (within BINGO susceptibility and sensitivity, will act as synonyms) is the degree to which the system is affected, depending on the own intrinsic characteristics of its exposed elements within the area in which hazardous events may occur. These intrinsic properties include, for instance, the physical characteristics of exposed elements (infrastructures, buildings, etc.), the economic and social context of the community, etc. For floods, for instance, important capacities are the awareness and preparedness of affected people and the existence of mitigation measures to reduce the effects of the hazards, like warning systems and emergency plans.
Resilience	Considered as the adaptive capacity of a system to endure any perturbation, like floods, droughts or other hazardous event, maintaining significant levels of efficiency in its social, economic, environmental and physical components; resilience to a hazardous event damages can be considered only in places with past events, since the main focus is on the experiences encountered during and after the events (ISO Guide 73:2009).

In conclusion, in a more social based risk approach, the risk can be assessed through the combination of the hazard likelihood and the vulnerability of the system referring to the propensity of exposed elements to suffer adverse effects when impacted by hazard events. In this framework, and according to Figure 1.4, vulnerability is related to exposure, susceptibility, and resilience of the exposed system to cope with and adapt to extremes and non-extremes.

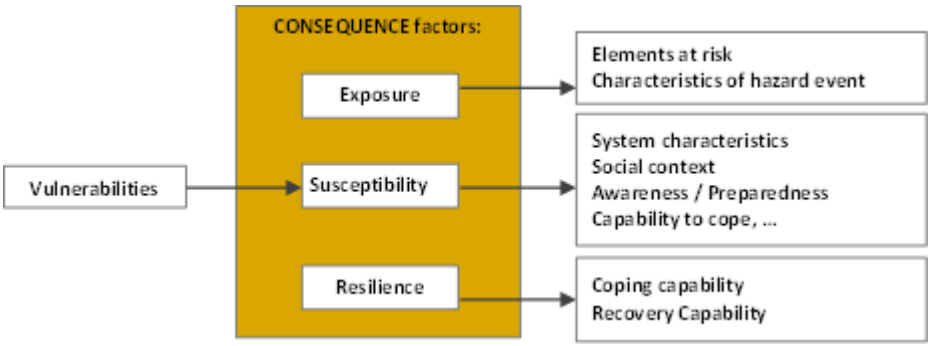


Figure 1.4: Factors affecting the consequences of an event

1.4. Structure of the document

The main purpose of this report is to identify and clearly formulate the adaptation objectives being addressed in BINGO project at each research site and to establish the context of the risk management process (RMP) in all sites.

Following this introduction, in Chapter 2, information requirements and methodologies to establish the internal and external context for the research sites are presented. Also, guidelines to identify the risk objectives and scopes within the BINGO project are provided as well as to establish the criteria to perform risk evaluation, including examples of thresholds and indicators based on respective EU Directives.

Chapters 3 through 8 present the risk context for each of the BINGO research sites. Each chapter is of the responsibility of the respective BINGO scientific partner team.

In Chapter 9 a summary is provided and the similarities and the singularities between the research sites are identified and analysed. This summary is presented bearing in mind the requirements of work package 5.

Finally, a risk glossary is presented in Annex I and Annex II contains recommendations to perform the following steps of the RMP in the six BINGO research sites.

2 GUIDELINES FOR ESTABLISHMENT OF THE RMP CONTEXT

2.1. Modus operandi used for developing deliverable D4.1

The modus operandi used for developing deliverable D4.1 followed the sequential approach:

1. Definition of the methodological approach to obtain the information to characterize the internal and external contexts for the categories of risk that are going to be managed in each research site. For this purpose it was produced a report "*Guidance on implementation of BINGO WP4 - Assessment of impacts of extreme weather events. Establishing the context for the risk management process"* (Rocha, 2016);
2. Production of all the necessary information, carried out by the stakeholders, supported by the WP4 scientific partners that coordinate each research site[1];
3. Harmonization among research sites of the objectives, scopes and contexts, including risk criteria;
4. Summary and identification of the similarities and the singularities oh the six sites, carried out by LNEC and supported by other scientific project partners. This summarization analysis was carried out envisaging the remaining activities of work package 4 and the adaptation strategies to be developed in work package 5.

A very first step within WP4, prior to the establishment of the risk management process context, consisted in getting an initial insight and understanding of the different research sites, as they address a wide range of water systems, strategic uses, and key problems (Figure 2.1). Therefore, it was considered important to clarify from the start

[1] In order to gather some of the necessary information, interaction with stakeholders was crucial. In fact, the most effective way of gathering information was addressed: searches in the web and at the sites of the stakeholders provided relevant information, telephone calls, email, questionnaires or other approaches were found useful. Note that, as designed in the BINGO work programme, the several workshops planned to take place within WP5 and WP6 activities were designed to create awareness and share views and information among researchers and stakeholders, in order to enhance the co-production of results. The workshops were, in fact, opportunities to gather relevant information concerning the establishment of the internal and external contexts.

which systems, events and end-users must be considered for each case, within WP4 BINGO work plan.

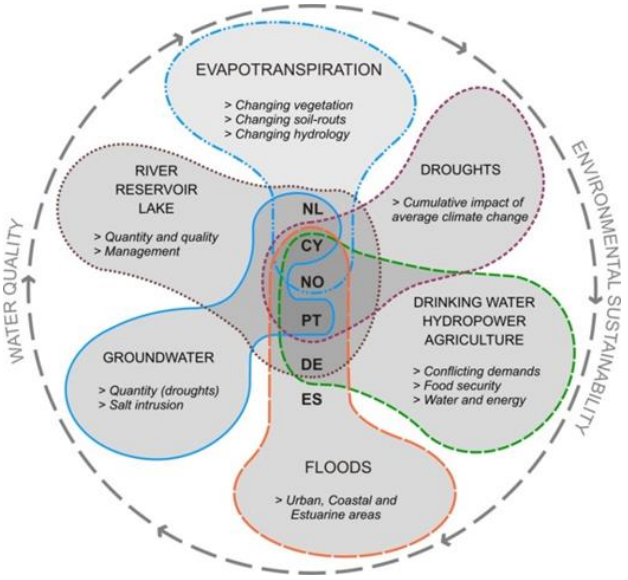


Figure 2.1: BINGO RS. Range of water systems, strategic uses and key problems addressed

In order achieve this overview, a template table (in Excel) was set up where all BINGO research partners introduced the main information regarding the objectives and focuses of their specific research sites. This matrix contained the following information:

- Physical systems and human activities to address (natural water cycle or urban water cycle / water resources management, public or economic sectors)
- Type of climate change extreme events to be addressed at each site (floods, droughts, sea level rise or storm surges) and characteristic of impact on the water cycle, ocean, or social tissue to be assessed (water resources quantity and/or quality, inundations, combined sewers overflow, etc.)
- Identification and distinction of the cases that will produce scientific knowledge or innovation for later decision making from those that will go through a risk management process
- Assembled Team (involved experts and RS stakeholders for risk assessment in WP4 and for risk treatment in WP5)
- Preliminary objectives and focuses of the risk assessment, for drawing the boundaries of information needed to establish in the overall context;
- Very preliminary criteria for risk evaluation.

The second stage within WP4 was to establish the risk management process **context** at each site. Following mainly the ISO 31000:2009, this establishment required:

- Identification of BINGO adaptation objectives;
- Definition of the extent of RMP development at each research site;
- Characterization of the research sites from the risk assessment point of view;
- Identification of the risk owners and key stakeholders;
- Identification of the risk management scope and objectives;
- Definition of the external and internal parameters to be taken into account (external and internal contexts);
- Identification of the criteria to evaluate the risk.

The general guidelines issued to pursuit these steps at the six research sites are referred below (chapters 2.2 through 2.8). They are fully presented in Rocha, 2016.

2.2. Identification of BINGO adaptation objectives

For each research site, a first insight must be provided, starting by identifying the climate change adaptation objectives being addressed in BINGO and referring how the risk assessment process of each research site will contribute to achieve BINGO final objectives. The type of extreme event or events being addressed and the possible water-related problems (inundations, droughts, etc.) must also be identified in the six BINGO research sites.

2.3. Extent of RMP development at each research site

For organizational purposes, the extent of RMP development at each BINGO research site must be clearly defined, identifying the different levels of analysis to be performed. In fact, all research sites will contribute to the definition of climate change adaptation strategies, although not all of them will go through a risk management process, or even through a full risk assessment process. According to the various steps of RMP (Figure 1.2), four possibilities of BINGO extents can take place:

i. Sites where the main objective is to increase the scientific knowledge, for example the study of evapotranspiration effect on water availability;
ii. Sites where the main objective is to produce knowledge for latter decision making, as for example the identification of the elements at risk under some CC scenarios; in this case research site does not go through a RMP; one or two steps of risk assessment can be performed: risk identification and analysis;
iii. Sites where the objective is to perform the three steps of climate change risk assessment (risk identification, analysis and evaluation) but do not procced to

risk treatment in WP5, although some only generic measures (not site oriented) can be listed in same cases;

iv. Sites that will carry out a full risk management process, including designing site oriented adaptation strategies for climate change related challenges in WP5.

2.4. Characterization of the research sites

Each research site must be characterized from the risk assessment point of view and the relevant features related to the activities being addressed described. In fact, the activities vary with the research site under study, being examples of those which can take place:

- *Public water supply systems (PWS*), where the aspects to characterize involve the water sources, water treatment facilities and other site features considered relevant for water supply production concerns;
- *Agriculture,* where the aspects to characterize involve the relative economic importance in the research site, water sources for irrigation, type of crops, irrigation practices, protection systems against salinity intrusion, or any other features affecting demand and supply balance;
- *Water resources management*, where the aspects to characterize involve main water resources features (storage capacity, quality), clients being supplied, concerns, etc.;
- *Flood prone areas safeguard*, where the aspects to characterize involve vulnerabilities, exposure, etc.

Whenever physical systems description is considered useful, reference to deliverable D3.1 must be carried out.

2.5. Identification of the risk owners and key stakeholders

The first key principle for effective and efficient risk assessment is that governance over the risk assessment process must be clearly established. When seeking adaptation for climate change impacts, measures must be taken at different levels, namely at the governmental level (water resources management and legislation, for example), at the private or public sector level (water supply, agriculture, energy), etc. Each BINGO site is different and can address one or more climate change drivers involving one or several intervenient entities, with different objectives while pursuing climate change adaptation. Therefore, several intervenient can contribute and have accountabilities at different stages which are often related with their entities' mission.

In this phase of development of WP4, the key point is to identify the intervenient entities in each research site that would perform the full RMP. In fact, only those can be considered as **risk owners in WP4**; the remaining being stakeholders[2]. After identifying which BINGO intervenient will act as risk owner within WP4, the process continues with the identification of the **key stakeholders** affecting the risk management process, including referring if they are involved or not in BINGO (as partner, community of practice) [3].

To identify risk owners and key stakeholders and their accountabilities, a template was prepared by LNEC and filled in for every site. This identification aimed essentially:

- Eliciting **risk information** – Who hold the information needed to identify the risks? Which range of stakeholders will assist in making this information complete?
- Understand the stakeholder's **perception of risk and their objectives;** this step was particularly relevant to assist on the definition of the objectives to perform risk assessment at each research site.

2.6. Identification of the risk management scope and specific objectives

Overall, the **scope** is the primary aim of the risk owner for the RMP and depends upon its priorities and objectives. The scope of a risk management process normally includes safety of population and environment protection aspects. Whenever economic sectors or activities are involved, the scope can also include economic aspects to strengthen the economic activity (aiming at the definition of policies to reduce the values of impacts and damages and/or of strategies to augment income targets, for example).

The risk management scopes to be defined in BINGO research sites can cover aspects such as:

2 At this point it is relevant to remind the definition of risk owner and stakeholder (Annex I):
i) Risk owner (ISO Guide 73:2009, definition nº 3.2.1.1): Person or entity with the accountability and authority to manage a risk;
ii) Stakeholder (ISO Guide 73:2009, definition nº 3.5.1.5): Person or organization that can affect, be affected by, or perceive themselves to be affected by a decision or activity. Note: A decision maker can be a stakeholder.

3 Note that at each research site, the majority of the end-users are already partners in the project – in fact, as already stated, they are the risk owners at each site. Nevertheless, there are also stakeholders that play relevant roles, but are not BINGO partners. Stakeholders may be from different sectors of activity, private or public, including Environmental Agencies or Government Regulatory Bodies.

- the continuity and sustainability of services in water production, for Public Water Supply systems case studies;
- strengthening of key economic activities, for agriculture case studies;
- the sustainable use of resources (water, energy, etc.) or the protection of the environment, for the water resources management case studies;
- The safeguard of people and property or the protection public health, for flood prone areas case studies.

Other general scopes, namely economical, as service profitability and avoiding financial losses, or concerning reputation and image can also be identified.

Once the overall scope is identified, the second stage is to articulate the **specific objectives,** which frame the following activities. Risks are identified and measured in relation to an entity's objectives or, more specifically, to the objectives defined for the risk assessment (ISO, 2009a). Specific objectives formulate the problem under analysis in a measurable way. In addition, **specific objectives** need to be aligned with the **criteria for risk evaluation** to allow completion of risk assessment.

As for example, the specific objectives for the public water supply scope "continuity of services in water production" can be translated by the following specific objectives:

- To supply water with adequate quality (i.e., that it will not harm customers' health);
- To supply water in adequate quantity (i.e., meeting every customer's needs);
- To supply water with adequate reliability (i.e., ensuring the continuity of the supply).

2.7. Identification of the criteria to evaluate the risk

The risk evaluation is the process of comparing the results of the risk analysis with "risk criteria" to determine whether the risk or its magnitude is acceptable or not. Risk evaluation assists the decision on which risks need treatment, which is based on the comparison of results from the risk analysis with a set of criteria previously defined[4].

[4] The definition of criteria for risk evaluation depends on: i) the risk management objectives and scope; ii) the nature and types of water systems to analyze, namely if they are natural ecosystems (catchment basins, reservoirs, estuaries and coastal waters) or anthropogenic systems (water supply systems or storm water and drainage systems, etc.); iii) the consequences to be included and how they will be measured; iv) the way how the level of risk will be determined; v) the views of stakeholders; vi) the level at which risk becomes acceptable and; vii) the responsibilities for accepting risk and at what level.

At the time the context was developed at each site of BINGO project, it was too soon to set tolerance levels, because views of stakeholders still needed to be discussed with the risk owners. Therefore, in this report, only the measures of risk significance were established, referred as risk criteria being “function of”. This way, the formulation of problems can be established at each research site, but tolerance levels will only be set in task 4.3 of BINGO (risk analysis and risk evaluation).

Note that criteria to be chosen largely depend on the scope and specific objectives defined for adaptation and for inherent risk management and therefore were judiciously defined by the risk-owners. Risk criteria also needs to be aligned with risk identification and risk analysis methodologies in order to be able compare with tolerance levels. Once again definition of risk analysis methods was a bit premature at this stage in BINGO, although there is a tendency for using probability - impact matrixes (or hazard-consequences). In Annex II, some guidance on how to perform these tasks are provided.

Criteria can be of different types, and can be expressed according to different variables and dimensions. For example:

- for **continuity of service** (water supply; electricity supply, etc.), criteria can be expressed in function of:
    - interruptions of the service (availability and compliance with minimum standards);
    - performance measures (e.g. client-hours lost without supply, number of interruptions) using thresholds derived from legal requirements;
    - various reliability measures (e.g. number of specific failures or failure modes per time unit), using thresholds derived from legal requirements;
- for **sustainable management of resources** (reservoir operation), criteria can be expressed in terms of:
    - thresholds for maximum reservoir outflow;
    - thresholds for reservoir levels, for groundwater levels, river flows and defining proper water allocation for water supply, irrigation, energy, etc.;
- for the **protection of the environment**, criteria can be expressed in function of:
    - severity (e.g. expected recovery time, water quality parameters);
    - extension (e.g. dimension of affected area or water body volume, volume or duration of event);

- vulnerability (e.g. protected areas, ecosystems of species at risk, areas of influence for water supply abstraction);

- for **safeguard of people and property**, criteria can be expressed in function of:
  - severity (e.g. flow depth and velocity runoff in public streets or water depths flooding in public or private properties);
  - extension (e.g. size of affected area or duration of event);
  - thresholds for losses and damages (number of people at risk or economic losses) derived from legal requirements or from good technical practices);

For the private sectors, thresholds can be dictated by economic management. In what concerns the objectives of public management bodies and the balance of water systems, they are also usually derived from legal requirements, as for example, from European Directives.

2.8. Information requirements and methodologies to establish the internal and external contexts

2.8.1 Introduction

The **internal context** is the environment in which the organization (risk owner) seeks to achieve its objectives and is established by the fully characterization of aspects related to governance (decision chain), objectives and planned results, resources available, etc. The **external context** is the environment conditioning the achievement of the organization´s objectives and is related to policies, legislation, standards, codes of practices, economic issues, etc.

The identification of the relevant conditioning factors is directly related with the scopes of the risk management processes formulated by the risk owners at each research site. In fact, the establishment of the context for the risk management process influences directly the formulation of the problem (scope) as well as the structure of risk analysis and risk evaluation. It can even determine the success of the process (Figure 2.2).

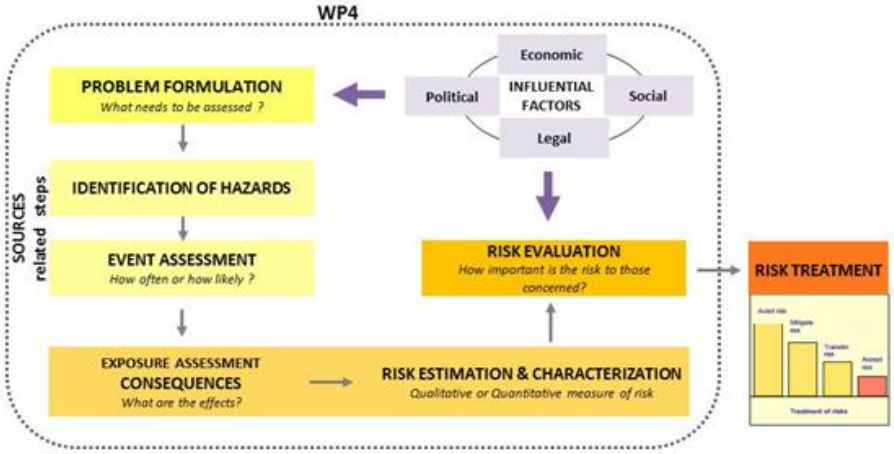


Figure 2.2: Impact of context establishment on RMP (Adapted from Csaba and Nikolett, 2008 and Heinz, 2010)

2.8.2 External context

The type of information that is needed for the establishment of the **external context** is the following:

1. Policies, standards and laws, regulations or codes of practice (European, national or regional/local) that must be adhered to are to be listed for all research sites and study environments. The focus lies on the following topics
   a. Regulation/legislation meant to protect the natural water system (depending on the research site situation);
   b. Regulation/legislation that the risk owner must comply with (e.g. regulating their sector of activity).
2. Key drivers, trends and other external factors affecting the organizational objectives whether local, regional, national or international:
   a. Economic trends.
   b. Sociological trends (cultural, social, demographic etc.).
   c. Technological trends.
   d. Environmental trends.

A PESTLE analysis is normally used to help organisations to identify and understand the external environment in which they operate and how it may change in the future. The PESTLE acronym stands for: Political, Economic, Social, Technological, Legal and Environmental (Table 2.1). As PESTLE is easy to understand and use, it is the methodology recommended in BINGO, allowing for comparison and harmonization across research sites and, more important, allowing easily to identify key conditioning factors relevant for later extrapolation of adaptation strategies being defined.

It is common to find a lot of interlinkages – for example policies under political factors leading to legal and environmental trends. The focus of applying PESTLE should therefore not be too strong on fitting each subject/factor into the right category, but to foster the understanding of the framework and picture the context as a whole.

2.8.3 Internal context

The general characterization of each organization contains the following information in order to establish the **internal context** (Table 2.2):

1. **Governance** of the risk owner (decision chain and relation with stakeholders).
2. Organizational **objectives** of the risk owner and **scopes** of the RMP (take into consideration BINGO's temporal horizon of 2025).
3. Planned **results** of the end-user activity.
4. Description of **resources available to the risk owner** (that are needed to support the organizational objectives, such as, staff; information sources; funding; infrastructures; technologies; equipment…).
5. What are the **strategies** that are already in place to achieve the organizational objectives?
    a. Strategies that are successful;
    b. Strategies that are not (so) successful;
    c. Strategies that are planned for the future.
6. What metrics could be used to define **success or failure** of the risk owner activity/objectives (**risk criteria**)?
    d. Flood risk examples: reduction in flood damages.
    e. Agriculture examples: area of land irrigated; crop yields.
7. What is the risk owner´s and stakeholder´s perception of risks (to what extent and level)?
8. What are the existing risk management expertise and practices?

Additionally, two main overview issues that must be addressed and properly evaluated in the definition of the internal context are:

9. Relationship of the risk owner with stakeholders and the different risk perceptions and values they may have.
10. Identification of conflicting objectives among the different stakeholders.

Although the scopes and risk criteria include the internal context, for development purposes within BINGO, it was easier to express them separately for team harmonization purposes.

Table 2.1: Establishment of the external context using PESTLE methodology

PESTLE	Some explanation	Key questions (types of questions we should ask)	Might include:
POLITICAL	These are the aspects of the political environment in which you operate, which have the potential to impact on your plans.	What are the key political factors?	→ Government type and policies → Funding, grants and initiatives (These might include political stability, Worldwide, European and Government Directives, national and local organization's requirements, institutional policy, tax policy, trade restrictions and reform.)
ECONOMIC	These are factors relating to the local, national or global economy	What are the important factors?	→ Funding mechanisms → Labour and energy costs → Liability → Inflation and interest rates (Funding mechanisms/streams; business/enterprise economical directives, internal funding models, budgetary restrictions, income generation targets; liability costs, growth/decline, interest rates, exchange and inflation rates, credit availability, unemployment rate, cost of living.)
SOCIOLOGICAL	Consider what is occurring socially in the "markets" in which you currently operate or plan to operate.	What are the important sociological factors?	→ Population, education, media → Lifestyle, fashion, culture (General lifestyle changes, demographic trends, population distribution, migrations, age distribution, education, cultural norms, fashions and trends and social expectations.)
TECHNOLOGICAL	The rate of change in new technologies is increasing.	What technological innovations are likely to occur?	→ Emerging technologies; WEB, for instance. → Information & Communication (Major current and emergency technologies of relevance for the sector/ goals, for instance, rapid developments in mobile phone technology and greater use of social networking sites may impact on your products and services.)
LEGAL	These could be things like changes in legislation relevant to the sector/company. What legal structures must your company operate within? Are there compliance requirements?	What current and impending legislation may affect the sector?	→ Regulations and standard → Other binding laws (Employment law) (Worldwide and national proposed and passed legislation, aspects relating imports/exports, taxation, access to materials, quotas, professional practice etc.)
ENVIRONMENTAL	This refers to what is happening with respect to ecological and environmental issues. Some of the environmental factors, however, may also be economic or social in nature.	What are the environmental considerations?	→ Climate, weather → Pollution → Ethical issues (Local, national and international environmental impacts, outcomes of political and social factors.)

Table 2.2: Establishment of the internal context

	Some explanation	Key questions (types of questions we should ask)	Might include:
GOVERNANCE & INTERNAL STAKEHOLDERS	Intend to identify the decision chain and services structure, and identify the person or sectors within the organization crucial for assisting in information gathering and risk management	What are the relevant Organization's Governance issues?	→ Decision chain within the organization → Services structure, person or staff groups crucial for assisting in information gathering and risk management
GOALS & OBJECTIVES	Intend to articulate the organizational **objectives** and planned **results** of the end user activity	What are the objectives and specific goals?	→ Clear objectives identification → Determine the significance of the activity in achieving the organization's goals and objectives → What metrics could be used to define success or failure of the activity/objectives?
STRATEGIES	Identify strategies that are in place to achieve the goals/ objectives	What are the **strategies** that are already in place to achieve the organizational objectives?	a. Strategies that are successful; b. Strategies that are not (so) successful c. Strategies that are planned for the future
RESOURCES	Description of **resources available to the risk owner** (that are needed to support the organizational objectives) *(Such as, staff; information sources; funding; infrastructures; technologies; equipment…);* Decide on the **depth and breadth** of analysis and allocate resources accordingly.	What capabilities does the organization have in terms of people, systems, processes, equipment and other resources to achieve the objectives?	→ staff; → existing Risk Management expertise and practices → information sources; → funding; → infrastructures; → technologies; → equipment…
INTERNAL CULTURE	Intends to identify inside organization resistance to adaptation	Is there an internal culture that needs to be considered?	→ Is there staff resistant to change? / professional culture that might create unnecessary risks ?

3 RMP CONTEXT AT WUPPERVERBAND RESEARCH SITE

3.1. Risk approach within BINGO

3.1.1 Adaption Objectives within BINGO

The German Research Site is the Wupper basin. As a result of a dramatic growth in industry and population in the end of the 19th century, waste and untreated sewage from businesses, factories, and households were discharged into the water bodies, turning the Wupper River into a sewer. In addition to environmental impacts caused by industrialization and population growth, the occurrence of floods and water shortages during dry periods affected towns and villages along the Wupper River, who were unable to solve all the water management problems by themselves. Therefore, the Wupper Association (WA) was established in 1930 in order to assume responsibility for water management within the catchment area. Over the past 20 years, the water quality of the Wupper River has been significantly improved by huge investments made by the Wupper Association, local authorities, and industrial companies. The water quality is currently so good that many species of fish have returned. Nevertheless, organic and thermal pollution prevails.

There is a manifestation of extreme climate events in the Wupper river basin which ranges from dry periods in spring time to heavy convective rainfalls in summer time and river floods caused by the combination of snow melting and rainfall during the winter seasons affecting raw water quality and quantity.

With regard to water management under climate change the following objectives for the risk management process of Wupper Research Site can be summarized:

1. Raw water provision during low precipitation events for members/customers according to contracts (water supply, industry), hydropower generation, environment (ecological flow) agriculture and leisure activities
2. Sanitation and water management/flood protection during heavy rainfall events/flooding
    a. Flood protection for infrastructure, public and private property, health and life according to principle goals of WA (i. e. management of surface water level, protection against floods for different annualities)
    b. Operation and maintenance of waste- and stormwater treatment assets according to legal requirements and contracts with members/customers

3.1.2 Research site description

The Wupper basin has an area of 813 km² and a population of ca. 950,000 inhabitants, ranging over several municipalities. Altogether 900 small rivers and brooks longer than 500 m are located in the basin (see Figure 3.1). The biggest river is the river Wupper with a length of 115 km.

Figure 3.1: Wupper River Basin

The Wupper River Basin has a wide range in the amount of Mean Annual Precipitation (MAP) of 775 to 1425 mm, as shown in Figure 3.2. On account of the higher rainfall amounts in the upper parts of the basin, the construction of large reservoirs started towards the end of the 19th century.

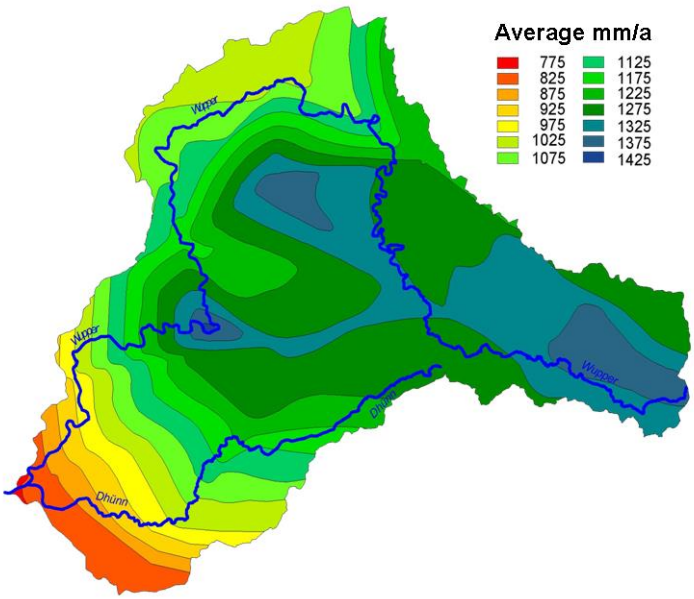


Figure 3.2: Spatial distribution of Mean Annual Precipitation (MAP) in the Wupper River Basin

The main water use categories within the Wupper River Basin are summarized as follows: service water, domestic water, and process or industrial water. Raw water is the sum of domestic water and process or industrial water. Service water refers to water used for reservoir and flood management and ecological flow regulation (e.g., reservoir storage); in this case, it corresponds to the direct withdrawal from the Wupper River. Domestic water is used for indoor and outdoor household purposes (including drinking water) as well as for small businesses. Process or industrial water is utilized e.g., for “cooling purposes” at power plants. Energy production falls roughly into the “process or industrial water” category.

The Wupper Association operates fourteen reservoirs - among other hydraulic infrastructure – with a total volume of 114 Mm³, fed by 21 rivers and creeks. The fourteen reservoirs fulfil different purposes regarding the water use categories. The reservoirs for raw water supply (including drinking water) are: Große Dhünn, Eschbach, Kerspe, Neye, Herbringhauser, and Sengbach reservoirs. Alone the Große Dhünn Reservoir - the second largest drinking water reservoir in Germany - supplies drinking

water for ca. 500,000 people, serving also as emergency water supplier for the city of Düsseldorf. Table 3.1 shows the supplied municipalities and population that benefit from the six raw water supply reservoirs.

Table 3.1: Supplied municipalities from the Große Dhünn, Eschbach, Kerspe, Neye, Herbringhauser, and Sengbach reservoirs (in terms of raw water, including drinking water)

Municipality (Gemeinde)	District (Kreis)	Gov. district (Reg.-Bez)	Municipality total population (in 2015)
Burscheid	Rheinisch-Bergischer Kreis	Cologne	18.064
Hückeswagen	Oberbergischer Kreis	Cologne	15.039
Remscheid	Kreisfreie Stadt	Düsseldorf	108.370
Wermelskirchen	Rheinisch-Bergischer Kreis	Cologne	34.297
Odenthal	Rheinisch-Bergischer Kreis	Cologne	14.688
Leichlingen	Rheinisch-Bergischer Kreis	Cologne	27.485
Wuppertal	Kreisfreie Stadt	Düsseldorf	344.421
Leverkusen	Kreisfreie Stadt	Cologne	161.713
Radevormwald	Oberbergischer Kreis	Cologne	21.908
Solingen	Kreisfreie Stadt	Düsseldorf	156.182
		Total	**902.107**

Water treatment as well as its later transport to the supply network is responsibility of five facilities: Wuppertaler Stadtwerke AG (WSW), Stadtwerke Solingen GmbH, Energie und Wasser für Remscheid GmbH (EWR), Energieversorgung Leverkusen GmbH (EVL), and the Rhein-Wupper Water Supply Association (WVVV).

The overall water demand - for raw water and service water - for the year 2015 was ca. 231.49 Mm^3/year.

The overall water demand - for raw water and service water - for the year 2015 was ca. 231.49 Mm^3/year.

Mean annual precipitation is relatively constant with respect to the weather normal distribution. Mean monthly precipitation during the 20th century shows a shift of the rainy season from spring (April) to summer (June/July). The shifting of the rainy season has a negative impact for the water quality and quantity within the reservoirs. For example, there was a three-year consecutive dry period (2012 – 2015), where the water level of the Große Dhünn Reservoir was alarmingly low. As a result, the alternative of inflowing extern water (extern inflow) is being currently considered.

Weather extremes have been well known in the last decades for the Wupper basin. Ranging from dry periods in spring time (important for filling the reservoirs) to heavy convective rainfalls in summer time (triggering flash floods occurrence, see Figure 3.3), and the combination of snow melting and rainfall during the winter season (causing river floods). Heavy recent floods have been recorded for 2007, 2011, and 2013, for both winter and summer seasons (e.g., the 2007 and 2011 floods occurred in December and January, respectively, and the 2013 flood took place in June).

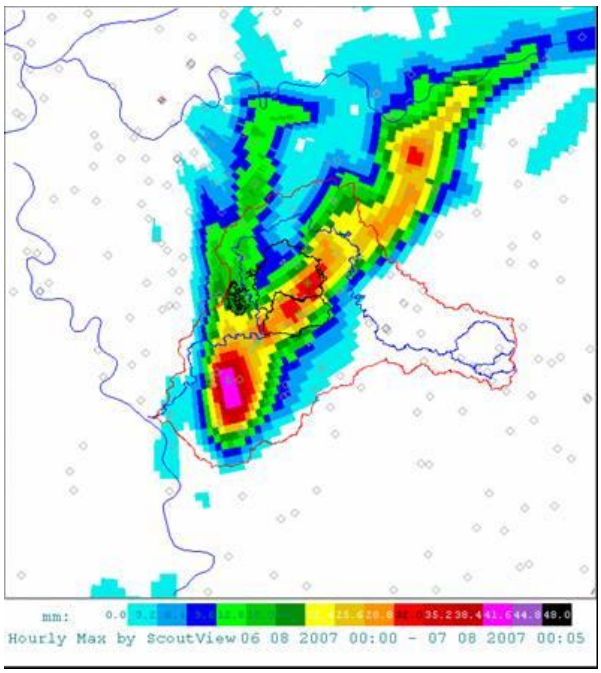


Figure 3.3: Flash flood occurrence along the Wupper river basin

3.1.3 Identification of risk owner and key stakeholders

The objective is the risk management for the main key problems described in chapter 3.1.4. WA is forced by legal requirements and by contracts with members to fulfil demands on water quantity and/or quality. In these cases, WA is the risk owner.

The following stakeholders have been identified to be relevant within the BINGO-project:

- Authorities such as Ministries, District Governments and Environmental Agencies
- Members and customers from Wupperverband (such as public water supply entities, industry using water for industrial purpose)
- Farmers

- Public
- Internal stakeholders (several departments of WA)

3.1.4 Risk objectives, scope and criteria to evaluate the risk

The risk scope in the Wupper Association research site include: people and property safety, service continuity, protection of environment, maintenance of good reputation and image, economic (external to WA), financial (WA). The risk scope is dependent from the individual objectives which have to be considered for the extreme conditions of low precipitation/droughts and high precipitation/floods.

1. Ecological flow

The Wupper Association has to provide reservoir management to ensure a minimum flow necessary to preserve individual species and river´s ecosystem in the rivers of WA´s catchment area. Water availability and reservoir management may be affected by CC, nevertheless, WA has to ensure the ecological flow. Authorities will have to define methods and specifications to determine ecological flows. Up to now this is a matter of discussion, but WA is the risk owner to guarantee the ecological flow. The objective within BINGO is the management of the risk to miss the target of sufficient water flow (i.e. water quantity) due to CC.

2. Provision of raw water - PWS

WA provides raw water for drinking water treatment and has to deal with water quantity and quality issues, which may be affected by CC. WA is not finally responsible for the provision of drinking water in a sufficient amount and quality to the customers, but is responsible for the provision of raw water in a sufficient amount to the drinking water suppliers. Contracts with water supply companies exist concerning the provision of the needed raw water quantity. Quality aspects are not contractually regulated. The WA is therefore the risk owner for raw water quantity. The objective within BINGO is the management of the risk to miss the target for provision of contractually fixed raw water quantity due to CC.

3. Provision of process water - hydropower

WA operates own hydropower plants. Even if there is no fixed limit of hydropower to be supplied to external customers, WA has the aim to produce as much hydropower as possible and to reduce the import of electricity from other companies. The WA is therefore the risk owner for the provision of as much hydropower as possible. The

objective within BINGO is the management of this task in combination with other tasks for water quantity management due to CC.

4. Provision of process water - water for industrial use

WA provides water used for industrial purposes (production, cooling or hydropower generation) which is taken from rivers by industrial companies. WA is committed by contracts to ensure a sufficient water flow for the industrial members. This comprises also a sufficient water flow for cooling purposes. Beside the management of the contractual ensured water amounts the WA has to consider maintaining the ecological flow as already explained. Therefore, WA is the risk owner for the provision of sufficient water for industrial use. The objective within BINGO is the management of the risk to miss the targets for water quantity for industrial use due to CC.

5. Provision of process water - agriculture

Within WA catchment area, groundwater and surface water is used for agricultural irrigation. By CC, surface water and groundwater level may be affected as well as floods may occur, which may result in a lack or excess of water and may reduce the crop yields or damage the fields but WA is not obligated by law or contracts to provide water in a minimum amount to agricultural collectives or farmers. Although WA is not the risk owner for the provision of sufficient water for agriculture, WA will try to consider the risk to miss the targets for water level (groundwater and surface water) due to CC within the other risk management tasks, it is obliged to.

6. Leisure activities

The river Wupper and the dams are used for multiple leisure activities like e.g. sailing, rowing, swimming, diving or fishing. At the riverside and the near environment biking and hiking trails as well as campgrounds are located. WA is not obliged by contracts with sport clubs or other NGOs or tourist associations to guarantee a water level and quality, which enables the leisure activities. Although WA is not directly the risk owner for the provision of an adequate water level and bathing water quality in the river as well as in the dams, the WA will try to consider the risk to miss the targets for surface water level and bathing water quality due to CC within the other risk management tasks, it is obliged to.

7. Infrastructure

The risk of flooding of infrastructure like e.g. roads, houses, industrial area may be increased by CC. The protection against floods is generally the duty of the owners of

infrastructure. Nevertheless, one of the main goals of WA is the protection of infrastructure and people against floods and to avoid or to reduce the risk of damages, even if no contractual or legal commitments exist. Furthermore, WA owns and operates own assets for water sanitation and hydropower generation like sewers, wastewater treatment and excess sludge combustion plants. Therefore WA regards itself as risk owner for flood protection. The objective within BINGO is the management of the risk to miss the targets for surface water level due to CC.

8. Sanitation

WA owns and operates assets for water management and sanitation and is the risk owner for a correct operation of the wastewater system and treatment plants, even under CC. Wastewater treatment plants effluents have to comply to legal demands, even under CC. Wastewater and stormwater management have also an influence on river water quality, which must comply to bathing water quality demands, if rivers or dams are used for swimming. The objective within BINGO is the management of the risk to miss the quality targets for wastewater treatment plants effluent or surface/bathing water quality due to CC.

The criteria to evaluate the risks are taking into account key objectives listed above. The listed items reflect the state of knowledge at the beginning of the project and it must be expected that the descriptions may change during the working time, because of the increase of knowledge and the intensification of cooperation between the WA, scientific partners and stakeholders.

The levels, where the risks will become acceptable are frequently already defined in some degree by the legal requirements. Nevertheless, it may be possible that stronger levels may be determined according to the (perhaps even already existing) agreements with stakeholders. Within the BINGO-Project these levels will be reviewed, updated or fixed according to the needs of adaptation to CC together with the stakeholders who have to accept the agreed risk levels.

Up to now, it is planned to implement the RMP in the total area of the WA. Nevertheless, it may be restricted to one or more selected sub-areas if implementation shows to be impossible for the total area within BINGO. In that case, the sub-area(s) may be seen as model cases for demonstration of the implementation.

The following tables show stakeholders, their objectives, and risk criteria, which will be part of RMP. Criteria to evaluate risks are mostly described instead of using numerical values. In some cases, these values have to be defined within the project. In other

cases they have to be derived from existing legal regulations or contractual commitments, which are too voluminous, specific or individual and are therefore not mentioned here in detail.

1. Provision of water during low precipitation events

The problem addresses rivers within WA catchment area in periods with insufficient rainfall or droughts. In Table 3.2, a summary of the main scopes and the criteria to evaluate these issues can be seen.

Table 3.2: Wupper RS – Objectives and scopes of the risk assessment processes of Wupperverband for droughts

Stakeholders/ Group of stakeholders	SCOPES	SPECIFIC OBJECTIVES	RISK CRITERIA Function of
Water utilities, industries, internal stakeholders (several dept. of WA)	Service continuity of water provision for members /customers according to contracts (i.e. drinking water treatment utilities, industries)	Assure sufficient volumes of water during 365 days/year for drinking water treatment and industrial costumers	• Nº of Days without sufficient raw water supply for drinking water treatment • Nº of Days without sufficient water for industrial use • Volumes: Missing amounts of raw water per day • Nº of Unsupplied customers (Customers minutes loss) • Nº of Un-/ undersupplied industrial companies
Authorities , Environmental NGOs, internal stakeholders (several dept. of WA)	Protection of environment	Assure ecological flow in duration and quantity, keeping of legal requirements and protection of environment	• Nº of Days with flow < ecological flow, • Volumes: Quantity of flow < ecological flow
Other end-users / Public	Maintenance of good Reputation and image	Needs and expectations satisfied	•Nº of reports in public media with critics or bad reputation
Internal stakeholders (several dept. of WA)	Financial (WA)	Production of hydropower, avoid WA financial losses	• Financial losses due to unprovided hydropower supply • Financial losses due to unprovided raw water • Financial losses on water supply entities or industrial companies caused by substitution of missing raw water

2. Flood management and storm / waste water treatment

In case of periods of high precipitation or flood, the key problem mainly addresses to

a. sites (infrastructure, public and private property) in the Wupper basin, where infrastructure may be affected by floods and
b. waste water and storm water management, which must comply with legal requirements.

In Table 3.3, a summary of the main scopes and the criteria to evaluate these issues can be seen.

Table 3.3: Wupper RS – Objectives and scopes of the risk assessment processes of Wupperverband for flood management and storm-/wastewater treatment

Stakeholders/ Group of stakeholders	SCOPES	SPECIFIC OBJECTIVES	RISK CRITERIA: Function of
Authorities, environmental NGOs, internal stakeholders (several dept. of WA)	Protection of environment	Keeping of legal requirements concerning treatment of waste/storm water, protection of environment	•Nº of Days without sufficient waste water treatment (effluent quality does not comply to legal requirements)
Authorities , Members/customers of WA, owners of infrastructure, public and others, internal stakeholders (several dept. of WA)	People and property safety	Management of surface water level, protection against floods for different annualities (depending on catchment and possibilities)	•Nº of people died or injured/flood •Nº of infrastructure, plants, houses destroyed/flood •Area of flooded fields/flood •Nº of floodings per year
Other end-users, owners of infrastructure/ public	Maintenance of good Reputation and image	Needs and expectations satisfied	•Nº of reports in public media with critics or bad reputation
Members/ customers of WA, owners of infrastructure, public and others	Economic (External to WA)	Avoid financial losses external to WA	•Costs for reparation of damages •Costs for loss of production
Internal stakeholders (several dept. of WA)	Financial (WA)	Avoid financial losses	•Penalty fees •Costs for reparation of damages

3.2. Establishing the external context

To avoid overlaps and repetitions, the PESTLE-analysis is summarised for all key problems (see Table 3.4).

Table 3.4: Wupper RS - External context for the RMP of Wupperverband

PESTLE dimension	RS KEY ISSUES	LIST	DETAIL
POLITICAL	Role of CC in policies	Taking into account programs and interests of political parties (EU, Germany, North Rhine-Westphalia, municipal) as well as programs and interests of industry (lobbies).	
ECONOMIC	Costs occurring form damages caused by CC, costs for CC adaptation measures	Financing of CC adaptation measures or CC-caused damage costs (i.e. member ship fees, existing funding instruments (EU, Germany North Rhine-Westphalia), insurances, protections and payments, need for creation of new funding instruments).	
SOCIAL	Level of information and awareness of general public	Needs for information (communication concept).	
TECHNICAL	Infrastructure/Technology development	Adaptation measures concerning observation and information/alarm, technical improvements, operational improvements, organisational improvements to meet water users targets	
LEGAL	Regulation and legislation (EU and national)	The characteristics of National and European laws, directives and agreements that drive and influence policies regulating water cycle (i.e. Water Framework Directive, EU-Bathing Water Directive, Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks, German Federal Water Act, State Water Act North Rhine-Westphalia, Spatial Planning Law, Wastewater Administration Regulation, Annex 1).	
	Contracting	The characteristics of contracts that drive and influence water management in Wupper region (i.e. Wupper Ordinance and Statute, contracts with drinking water suppliers as well as with cities and municipalities).	
ENVIRON-MENTAL	Local CC-occurrence and impact on infrastructure	The changes in precipitation, temperature and extreme events patterns (magnitude of local CC, effects of CC on technical infrastructure).	
	Quality and quantity targets	Definition of quality and quantity targets for different kinds of water use, which must be kept under CC (e.g. amounts of water for drinking water treatment, hydropower, agriculture, leisure activities and related quality standards or requirements).	
	Water quality	The changes in water composition in terms of quality (pollutant load) and temperature.	
	Water availability	The changes in average water flow available in catchments, for drinking water treatment, hydropower, agriculture, leisure activities and related quality standards or requirements.	

3.3. Establishing the internal context

The internal context may be explained for each key problem listed in chapter 3.1.4, but it was decided to summarise the internal context for all key problems to avoid overlaps and repetitions.

1. Governance & Stakeholders

a) Decision chain within the organization

Members of WA (cities and municipalities, counties, businesses and institutions of public water supplies, the owner of plants related to the water bodies) form the association assembly, composed of a maximum of 101 delegates. This elects the association council of 15 members, which elects the chairman, his permanent proxy and head of Personnel and Social Affairs. Additionally, delegates from the association assembly are forming the following committees: Finance Committee, Investment and Construction Committee and the Conflict Committee. For the individual bodies, the templates for decision making are prepared by the employees of WA.

b) Services structure, person or staff groups crucial for assisting in information gathering and risk management

An own department for water resource related data exists. The staff has access to databases from state and federal government organizations like the German Weather Service, environmental agencies and so on.

c) Stakeholders

According to the external context described in 3.1.4, the following stakeholders for the Research Site WA were identified:

1. Authorities
    a. Federal authorities and ministries, i. e.:
        - Ministry for Climate Protection, Environment, Agriculture, Conservation and Consumer Protection of the State of North Rhine-Westphalia
        - State Office for Nature, Environment and Consumer Affairs of North Rhine-Westphalia
    b. Environmental Agencies
    c. District Governments
2. Representatives of companies (not detailed)
    a. Water Utilities
    b. Energy Utilities

c. Waste Water Utilities

3. Others (not detailed)
   a. NGOs (such as environmental NGOs. sports clubs, tourist associations, German Insurance Association, etc.)
   b. Farmers
   c. Customers.

2. Goals & Objectives

a) Goals, objectives and activities to achieve them

The slogan of the association is: “Wupper Association: for water, humans and the environment”.

Thereby 'water' stands for the management of water quantity and quality within its territory. The human being is the focus of all activities, in their water related environment with their right to clean drinking water, their needs for protection against floods, their claims for an orderly, hygienic sanitation, their needs for recreation in an ecologically intact landscape, but also considering economic relations and social development. The term 'environment' illustrates the sensitivity towards global issues such as climate and resource protection, and the willingness of a positive contribution within the possibilities. The association wants to help shape the energy turnaround and focus on the expansion of renewable energies.

There are seven guiding principles to gain the goals:

1. Sustainable environmental protection in the catchment area of the Wupper at reasonable costs and conservation of resources
2. Balance between economic and ecological requirements
3. Promoting environmental awareness
4. Efficient provision of services
5. Creation of acceptance of WA as competent company for its members and for the population
6. Partnership and sensitivity to the needs of our members
7. Social responsibility

b) Metrics used to define success or failure of the activity/objectives

Targets and standards for required environmental conditions are defined by different laws, specifications and conventions. Those conventions include financial framework

conditions, milestones and time tables. For the rehabilitation of rivers and for flood risk management, a monitoring is already implemented: development of the river conditions and risk potential. For drinking water, the needed amount of water can easily be compared to the supplied amount (and the related costs) or necessary measures. The comparison of alternative measures and their expected result is an instrument to find the balance between economic and ecological requirements. For sanitation, the amount of treated waste water and monitoring the quality parameters towards cost can be benchmarked. An economic plan has to be set up every year and is controlled by the association assembly.

3. Strategies

a) Strategies that are successful:

1. Intelligent and efficient fulfilment of the statutory tasks

2. Performance-based contributions for the members of the WA

3. Efficient performance for a sustainable water management within its territory

These strategies are already used to fulfil the responsibilities of WA. Within the BINGO project, the applicability of these strategies under CC will be evaluated and the strategies will be improved according to the results if necessary.

b) Strategies that are not (so) successful; strategies that are planned for the future:

Up to now, the existing strategies showed to be successful. New strategies may be developed within this project.

4. Resources

The following resources are available to support the organizational objectives:

a) Staff

In order to provide the various services as a company in environmental protection, the WA employs approximately 350 employees with professional qualifications from different professional sectors: In addition to the predominantly technically trained staff, including the fields of engineering, supply and disposal (sewage), technology and laboratory, also employees from the fields of law, business, management and computer science are employed.

b) Existing Risk Management expertise and practices

The WA is responsible for the maintenance of different technical facilities and flood protection, and risk analysis is part of the routine business. In the field of economics the WA has accrued reserves.

c) Information sources

As already described, there are different computer based data bases and tools for collecting, managing, analyse and provide data and information.

d) Funding

As already described, the WA is mainly funded by the fees of its member. Additionally, a lot of measures are also funded by public funds, e.g. development programmes or compensation allowances.

e) Infrastructure

The infrastructures include:

- 14 dams
- 27 flood detention basins
- 11 wastewater treatment plants
- 1 sludge incineration plant
- Several main sewers
- Multiple stormwater overflow basins, stormwater retention basins and retentions soil filters
- 1 wastewater and 1 limnological laboratory

f) Technologies

There are plenty different technologies related to the several tasks the WA has to fulfil. As a key player in the field of public services - the water management - the WA always has to keep the necessary technical standard: dams, waste water plants, sewer, basins, measurement equipment and so on.

g) Equipment

Technical equipment for control and care of about 2,300 km of watercourses.

Multiple water gauges and multiple meteorological observation stations.

Several models for river basin management.

5. Internal Culture

To meet the increasingly complex processes in the duties, to use existing data and information as a knowledge base and engage in the exchange of knowledge with colleagues and externally, the promotion of corporate communication and knowledge management is of great importance. Therefore the communication and moderation skills of individual employees are trained. This should accompany difficult projects from the outset and thus provide assistance for the efficient handling of these projects.

Knowledge management at WA has the task of structuring and bundling existing data and knowledge, e.g. in form of project reports, minutes, memoranda, correspondence, etc.. To achieve this, the WA established a reporting database containing the above mentioned documents. The database allows a transparent view of the various topics, such as by the search function or the ability to sort information by subject or meeting.

Competence development of employees also means skills development for WA customers and members.

4 RMP CONTEXT AT THE VELUWE RESEARCH SITE

4.1. Risk approach within BINGO

4.1.1 Research site description

In the Netherlands, the BINGO research focuses on the Veluwe, a natural area that lies in the heart of the country (see Figure 4.1). It consists of about 125.000 hectares of land, encompassing the territories of 18 different municipalities. Around 80% of the area is covered by natural vegetation, mostly forests. While the Netherlands is a low-lying country, parts of the Veluwe are hilly with a moraine reaching a height of 110 meters in the south. Its sandy hills were formed in a glacial period about 150.000 years ago.

Figure 4.1: Location of the Veluwe research site

The area was home to the first agricultural communities in the Netherlands that settled on the Veluwe's hills to stay safe from the floods that regularly raged over the country. Forests were cut to sustain agricultural development, however, the Veluwe's sandy soils were not very suitable for large-scale agricultural production. Agricultural activity gradually declined and people moved to the fringes of the Veluwe, where groundwater levels are higher and the region's good quality groundwater resources could more easily be accessed. While some forests regenerated at the Veluwe, large parts of the

land are purposefully kept open through grazing. The Veluwe now has a unique landscape in which forests and heath land alternate (see Figure 4.2), providing home to many wild animals and cattle. A large part of the Veluwe (90.000 hectares) is protected by a Natura-2000 status. It is the biggest land-based Natura 2000 region in the Netherlands and a popular tourist destination.

Figure 4.2: Nature at the Veluwe (source: https://www.naturesgift.nl/shop/fietsen-over-de-veluwe.html)

The Veluwe has rich groundwater resources. The groundwater table is characterized by a large underground groundwater resource (a freshwater bubble), which feeds 20 to 30 small stream valleys and springs or brooks (man-made streams) that run downstream to the fringes of the Veluwe. The yearly input into the Veluwe water system (rainfall excess, calculated as rainfall minus evapotranspiration) is 350 – 550 million m^3, with a computed average of 1 mm a day and 456 million m^3 a year. Estimates of the base flow of these systems range from 30 to 50 million m^3. Altogether, 22 pumping stations with a total volume of 110 million m^3 regulate the Veluwe water system.

The Veluwe's water system has serviced and still services different activities. In the 18th century, the groundwater system of the Veluwe was used to provide energy to the region through watermills. In the 20th century, the Veluwe's groundwater provided a reliable source of good quality water for the chemical and paper industry, sectors which have reduced but still operate in the region. Small-scale farming (mainly cattle) also still exists. Since the 21st century, the Veluwe's groundwater resources are used as a drinking water resource. Drinking water is abstracted from a century-old underwater reservoir, which although not protected by a natural clay bed, is safeguarded from contaminations due to its deep-lying position. Besides these services, the water system also sustains the ecological and landscape quality of the region. The heath lands and the various streams and brooks are characteristic of the region, and draw a lot of recreational visitors and tourists all year round.

4.1.2 Adaptation Objectives at the Veluwe within BINGO

Climate change can potentially have major impacts on the Veluwe, however, different effects are connected to different impacts and their combined effect is not always straightforward. On the one hand, dryer and warmer summers will affect groundwater levels. The combination of less precipitation and more evaporation will limit groundwater recharge, causing problems to several functions dependent on the groundwater system. Springs and brooks may dry out at the fringes of the Veluwe, the nature of vegetation may change (threatening not only the direct goal of nature and landscape conservation but also all the services dependent upon the Veluwe's natural system such as tourism) and agriculture may also experience negative effects. In the long-run, it may also affect the availability and quality of the drinking water resource. In addition, the risk of forest fires may increase.

On the other hand, winters will be wetter and a surplus of water may cause problems, especially at the lower-lying fringes of the Veluwe. The rainwater that infiltrates in the central part of the Veluwe is discharged through the springs and brooks, and the groundwater system, to the fringes where water stress and floods may occur.

Strikingly, increased groundwater recharge in the winter may partly compensate for the effects of dry periods in the summer. However, the extent to which this seasonal groundwater compensation provides a solution not only highly depends on the climate scenario and the actual impacts of climate change on the regional water system, but also on the way in which the Veluwe's (ground)water system is managed.

The adaptation objective within BINGO set out for the Veluwe is to sustainably manage the regional water system in order to ensure a good ecological and landscape quality and the provision of raw water for public water supply to continue to meet demands under a future of climate change.

4.1.3 Identification of risk management processes at the Veluwe research site

In line with the risk management approach followed in BINGO, the remainder of this chapter maps out the risk management processes at the Veluwe. The adaptation objective outlined above falls into the scope of two different subdomains of water management: water resource management and public water supply. Below, risk management processes and contexts are identified for these two subdomains.

4.2. Subdomain 1: Water resource management

4.2.1 Identification of risk owner and key stakeholders

In the Netherlands, responsibilities for the management of water resources are distributed over different governance actors. Regional water boards are responsible for the management of surface water resources in their area. Furthermore, water boards see to the licencing of most groundwater abstractions (< 150.000 m^3/year) and (industrial) discharges at the water system, based on national-level legislation. Water boards are also responsible for the implementation of the EU's Water Framework Directive. Provinces are responsible for the management of groundwater resources within their jurisdiction. They licence large industrial (>150.000 m^3/year) groundwater abstractions and drinking water extractions. In the Netherlands, most aspects of ecological and nature management have been dissolved to the regional level where provinces receive national funding to develop and implement nature and ecological management plans to achieve national-set goals.

In the Veluwe, surface waters (springs and brooks) are inextricably linked to the groundwater system and in addition provide important ecological, landscape and nature values. Therefore, it is the province of Gelderland who is primarily responsible for ensuring a sustainable management of the Veluwe's water resources under a changing climate. In this sense, the province is the "risk owner"; it is the province that is principally responsible for the sustainable management of the Veluwe's water resources under a changing climate.

However, the provincial government closely collaborates with other actors involved in managing the water system at the Veluwe. The province for example often joins hands with the water board Vallei & Veluwe, responsible for the day to day management of the surface waters in and close to the Veluwe. From the cleaning of streams in order to maintain ecological flows to the development of strategic management plans for water management, the province and the water board closely cooperate on a regular basis.

Another important stakeholder is the water company Vitens, which uses the Veluwe's clean groundwater resources as a principal source for the its public water supply. Vitens has a direct stake in good groundwater management of the province and both actors together work to protect the Veluwe's groundwater resources.

Besides these two key stakeholders, there are many other actors and organizations that have a stake in, influence, or are affected by the provincial management of the Veluwe's (ground)water resources. Specified according to type, these are:

- Agencies and NGO's for nature management and forestry. At the Veluwe, most forests and natural areas are managed by nature-based agencies or NGO's. Because the Veluwe water system is dependent on groundwater storing capacity and the level evapotranspiration of this vegetation, these NGOs and agencies play an important role in the research site. The three most important agency of this type is Staatsbosbeheer, a regulatory agency of the Ministry of Economic Affairs responsible for nature and forestry management), and the NGO's Natuurmonumenten and Gelders Landschap en Kastelen.
- Private landowners are another important group of end-users. Because there are many different landowners, contact with this group is established through the association of private landowners (Gelders Particulier grondbezit) at the Veluwe, or through de Bosgroep, the association of forest owners.
- There are several NGO's that do not directly manage natural or forest land but encourage the sustainable use of these lands at the Veluwe. For example, the foundation of springs and streams (de Bekenstichting) focuses on the preservation of historical and ecological values of springs and streams in the Veluwe area. Other important NGO's of this type are the Stichting Natuur & Milieu, Milieuzorg Noord-West Veluwe, KNNV/NEW, Platform Water Vallei & Eem, Stichting Nauur- en Milieuzorg Noord-West Veluwe.
- Another important group of stakeholders is formed by higher-level policymaking and administrative entities. EU water policies affect regional water management, mainly through the European Water Framework Directive and the related Groundwater Directive. At the national-level, policymaking on water mainly takes place at the Ministry of Infrastructure and the Environment. However, while strategic goals and plans are developed at the ministry, important advisory and water management tasks have been delegated to Rijkswaterstaat, a regulatory agency responsible for the design, construction, management and maintenance of the main infrastructure facilities in the Netherland. Furthermore, while the Ministry of Infrastructure and the Environment has environmental management in its portfolio, the Ministry of Economic Affairs regulates the exploitation of forest and natural lands. Therefore, this ministry is another important stakeholder for the province.
- Also, there are governmental stakeholders at a lower level of governance. For water management, the policies made and decisions taken at the spatial planning departments of local municipalities are very important. Municipalities work with land-use plans which designate functions (e.g. residential, industrial,

nature) to different areas within their jurisdiction. In these plans, it is for example indicated where new developments may take place, and where space should be reserved for water retention.

- Last, an important group of stakeholders is formed by businesses and individuals. These are not only individual residents who for example bore a whole in their garden to place a fountain, but also private entities conducting their businesses in the Veluwe, such as tourist operators, farmers and the timber industry.

4.2.2 *Objectives, scopes and criteria to evaluate the risk*

For the provincial government, the adaptation objective is to sustainably manage the Veluwe's (ground)water resources, under different climate scenario's and in different seasons (where low precipitation and high evapotranspiration is expected in the summer and more and more intense rainfall is expected in the winter months). Sustainable in this context means that the water system of the Veluwe should safeguard ecological and landscape values, and ensure a sufficient quantity and quality of groundwater for public water supply, under changing climatic circumstances. The main question for the provincial government in this respect is: Are we at the boundary of sustainable use or can this system provide more ecosystem services?

This adaptation objective further translates into different "problem scopes" of the provincial government. Under the first scope, the province strives to ensure the provision of sufficient water resources with a sufficient water quality for public water supply (PWS). Under a second scope, the provincial government seeks to improve the natural, landscape and cultural heritage qualities of the Veluwe through sustainable groundwater management. Under a third problem scope, the province tries to provide sufficient volumes of groundwater for the maintenance of surface waters (water streams).

For these different problem scopes, the provincial government works towards specific objectives for which different risk criteria have been formulated. Under the first problem scope of ensuring resources for future water supply, the goal is to optimize the level of allowances for the extraction of water for public supply. The criterion to assess success and failure is determined by volume; when the demand for drinking water exceeds the current level of allowances (volume demanded - volume allowed > 0), a critical border has passed. Under the second scope of ecological and cultural heritage protection, the specific objectives are to minimize the economic impact on regional tourism and to

ensure the Natura-2000 are met now and in the future. When the tourist revenues (measured in euros/year) decline, or when there is a reduction in the number of protected habitats, and plant and animal species, these objectives are not achieved. For the last problem scope of surface water management, the specific goal is to ensure a sufficient flow in water streams so that streams do not dry out and the ecological quality in the streams is sustained. This objective is measured based on the number of streams (32 in total; of which four have a Natura-2000 status) that have a flow that sustains the ecological flow, and related to this, the number of protected species in the streams.

The Table 4.1 summarizes risk management process for adaptation to climate change in the Veluwe's water resources management domain.

Table 4.1: Veluwe RS – Objectives and scopes of the risk assessment processes of the Provincial Government (water resource management)

RISK OWNER	OBJECTIVES	SCOPE	SPECIFIC OBJECTIVES	RISK CRITERIA
				Function of:
PROVINCIAL GOVERNEMENT	Sustainable GROUNDWATER management *under different climate scenario's and seasons*	Provide water resources for public water supply (PWS)	Optimize the sustainable level of allowances	Volume: Demand of PWS exceeds current level of allowances (Volume demanded - volume allowed > 0)
		Protect and inprove the natural, landscape and cultural heritage qualities of the Veluwe through sustainable groundwater management	Minimize economic impact on regional tourism	Euros: negative economic impact on tourism
			Meet Natura 2000 objectives	Reduction in number of protected habitats, and plant and animal species
		Provide sufficient volumes of groundwater for the maintainance of surface waters (waterstreams)	Ensure ecological flow in water streams	Nº streams (32 total; 4 N2000) with flow < ecological flow; Nº of key species in stream

4.2.3 Establishment of the external context

For the establishment of the external context, WP4 employs the PESTLE approach. In Table 4.2 below, this approach is applied to establish the external context of the province with respect to its responsibility for organizing adaptation to climate change in the subdomain of water resources management.

Table 4.2: Veluwe RS - External context for the RMP of the Provincial Government

PESTLE dimension	RS KEY ISSUES	LIST
POLITICAL	Policies on groundwater protection	Changing policies on groundwater protection; the national government has recently initiated an exploration into "strategic" groundwater reserves that should be protected to ensure future water demands. The Veluwe is part of this exploration.
	Governance structure	The division of responsibilities between state, province, water board and drinking water company for water resource management will probably remain the same (no changes foreseen). However, in the governance field of spatial planning, responsibilities are currently shifting more to the local level as a result of new legislation (De Omgevingswet). These changes may impact on provincial water resources management because these changes will give municipalities more autonomy in drafting their land-use plans and deciding on which activities are and are not allowed.
ECONOMIC	Development in national and regional economy	Development of national economy: increase in water use. Development in regional economic and tourism sector: increase in pressure on Veluwe. Change in water resource pricing and cost recovery: Can landowners be paid for extra water production?
SOCIAL	Changes in attitudes	The Veluwe system provides important ecosystem services: a change in attitude towards ecosystem services can have an effect on key issues.
	Effects on appreciation	Will the change in vegetation and management of natural vegetation change the public appreciation of the Veluwe?
TECHNOLOGICAL	Sustainable technologies	Development of sustainable technological solutions for ecological challenges, such as horizontal drilling for groundwater recharge.
LEGAL	Legal framework	In the study area the following laws are important in relation to the key problems: Water frame work directive (2000/60/EG), Habitat directive (92/43/EG), the drinking water law (July 2009), the Water law (January 2009), Provincial spatial planning regulations (July 2015), Policy on strategic groundwater resources, ministry of infrastructure and environment, 2015.
ENVIRONMENTAL	Vegetation	Change in vegetation cover due to climate change can through evapotranspiration affect underground hydrology.
	Land use	Change in land use due to new policies on groundwater protection or new economic activity (these changes are connected to the decentralization of responsibilities for spatial planning).

4.2.4 Establishment of the internal context

Internal structure

The province is a regional governmental entity in the Netherlands. This entity is separated into three units. The States Provincial is the elected body of the provincial government. They formulate the goals and guidelines for policy making at the provincial level, and check whether these goals and guidelines are sufficiently followed by the executive branch. The States Deputed form the executive body of the provincial government; they translate the goals and guidelines formulated by the States Provincial into policies and rules. Both States are chaired by a Commissioner of the King.

Resources

The province has the following resources available to support its organizational objectives:

a) Staff

In order to implement the policies on nature management and drinking water protection, the provincial government, employs a sufficient number of people with professional qualifications in environment and water. Technical employees as well as experts from the fields of law and management are employed.

b) Risk Management expertise and practices

While the province has itself relevant experience and expertise in developing risk management strategies for water-related problems, it benefits greatly from the its many contacts with a wide network of other governmental agencies (e.g. water boards and municipalities), landowners, sector regulators, NGO's and businesses.

c) Information sources

Through this network, information is actively shared. There is an intensive network of measuring wells, a database with recent and historical data, and an existing 3d model are available.

Internal culture

As already stands out from the above, to meet the increasingly complex processes in their duties, the provincial government increasingly seeks to achieve its goals in cooperation with other partner organisations and stakeholders. In the last 15 – 20 years, considerable experience in this field was developed. Therefore the cooperation

and moderation skills of individual employees are trained. This should accompany difficult projects from the outset and thus provide assistance for the efficient handling of these projects. Competence development of employees also means skills development for our partners.

Existing practices and future strategies

The provincial government has applied several strategies in its current management of the Veluwe's (ground)water resources. Successful strategies have been:

1. Only allow groundwater use for high quality objectives.
2. Share knowledge of the water system.
3. Involve all stakeholders in important policy changes.

However, the province also looks ahead. Strategies that are planned for the future are developed based on the following guiding principles:

4. Environmental protection of the groundwater pumping stations.
5. Balance between economic and ecological requirements.
6. Efficient provision of services.
7. Partnership and sensitivity to the needs of other stakeholders.
8. Efficiency and effectiveness of use of the water system.

Whether these new strategies will be effective (metrics for success) will be tested against the risk criteria formulated in Table 4.1. The levels where the risks will become unacceptable are frequently already defined in some degree by legal requirements. Nevertheless, it may be possible that stronger levels may be determined according to the (perhaps even already existing) agreements with stakeholders. Within the BINGO-Project these levels will be reviewed, updated or fixed according to the needs of adaptation to CC together with the stakeholders who have to accept the agreed risk levels.

4.3. Subdomain 2: Public Water Supply (PWS)

4.3.1 Identification of risk owner and key stakeholders

In this section, the risk management process in the subdomain of Public Water Supply will be mapped. Partly, this process overlaps with the processes described in the subdomain of water resources management. However, the processes in this section are described from the specific risks that face subdomain of PWS, and the specific

adaptation objective that has been formulated in this regard: the provision of raw water for public water supply to continue to meet demands under a future of climate change.

According to the Dutch national Drinking Water Law, drinking water supply is a public good, which is protected by a governmental duty of care. In practice, public water supply is placed in the hands of ten drinking water companies, who sell and service drinking water to different end-users. Drinking water companies have the legal responsibility to supply clean and safe drinking water at the lowest socio-economic costs. While provincial governments and water boards, supported by the national government, designate and safeguard water resources for public water supply, it is the task of drinking water companies to make sure drinking water is supplied to end-users 24/7, 365 days a year, as well as to ensure that the water they supply meets the quality norms. These quality norms are based on the norms laid down in the EU Water Framework Directive and further specified for the Dutch context in the national Drinking Water Decree.

At the Veluwe, this responsibility falls on the shoulders of the drinking water company Vitens. Vitens is the largest drinking water company of the Netherlands; its service area encompasses five provinces, it exploits 108 groundwater resources, its infrastructure accounts to a total length of 47.500 kilometres, and its infrastructural and extraction assets represent a total value worth of 7.7 billion euros. The Veluwe lies within its service area but more importantly, many of Vitens' groundwater extractions are located in and around the region.

From the specific responsibility assigned to Vitens to ensure the continuous supply of good quality drinking water to end-users, Vitens is a "risk owner" in its own right; it has to cope with risks of pollution and contamination of the drinking water resources it extracts from. The relation between this risk-ownership of Vitens and that of the province described in the previous section should be understood in terms of a chain. The province is the risk owner of potential threats that face the Veluwe's (ground)water resources and in managing these threats, the province has to decide how much water can be extracted from the water system to ensure its resilience, and how extraction rights can best be allocated between different sectors in this light. Vitens is thus a stakeholder of the province in this respect. However, after the province has distributed extraction allowances over different sectors and users, including Vitens, the drinking water company has to manage its responsibility within the boundaries set by the province. While the province remains legally responsible for ensuring a good groundwater quality, in practice, there is a grey area between norms for soil

remediation and drinking water norms, which threatens Vitens' supply of good quality drinking water that meets the legal standards. To make sure the groundwater quality does not fall below the legal threshold, Vitens continuously monitors possible sources of contamination and takes action if these sources threaten its abstraction sites. For the specific responsibility of ensuring the continuous supply of good quality drinking water to end-users, Vitens is the risk owner and the province is a very important stakeholder, influencing the basic conditions under which Vitens operates.

Other stakeholders of Vitens are:

- European policy making units and agencies. For example, the European parliament and Commission have been considering the need enforce the privatization of public water supply throughout Europe, a discussion that pops up once in a while and would have a huge impact on the existing organization of public water supply in the Netherlands. Another European stakeholder of Vitens is the European Investment Bank, which co-finances some of Vitens' international assistance and collaborative initiatives.
- But Vitens also partners up with national-level policy making institutions; the company acts as an advisor on the development of new policy frameworks and guiding instruments. The Ministry of Environment and Infrastructure in an important stakeholder in this respect. Another important stakeholder at the national level is the Human Environment and Transport Inspectorate (ILT) of the Ministry of Infrastructure and the Environment, which monitors and checks compliance with the water quality norms laid down in the Drinking Water Decree.
- Stakeholders of Vitens are also those who influence the area in which the company operates. These include governmental agencies, such as regional water boards and municipalities. But area stakeholders also include non-governmental organizations and actors that operate in the Veluwe region, such as private industries.
- Last, an important group of stakeholders is formed by the clients of Vitens: households, farmers and industries.

4.3.2 Adaptation objectives, scope and criteria to evaluate the risks

For Vitens, the adaptation objective is to ensure the efficient production of drinking water in different climate change scenarios.

This adaptation objective of Vitens translates into two different problem scopes, each with its own specific objectives and risk criteria. First, the company continuously works to uphold service continuity. Under this problem scope, the objective is to assure sufficient volumes water supply during 365 days a year for domestic and industrial water supply. The number of minutes in a daily average flow with no supply is set as a criterion against which the performance of Vitens on this objective is assessed.

A second problem scope relates to the reputation of Vitens. With many stakeholders in the area, Vitens has to collaborate with these stakeholders to fulfil its objectives and the reputation of the water company is of crucial importance for successful stakeholder interaction. The specific objective here is to keep and improve the positive image of Vitens as a sustainable and environmentally friendly company. This objective is assessed based on the number of reports in the public media with bad critics.

Table 4.3 summarizes the risk management process for the subdomain of PWS in the Veluwe.

Table 4.3: Veluwe RS - Objectives and scopes of the risk assessment processes of Vitens (PWS)

ACTIVITY/ SECTOR	RISK OWNER	OBJECTIVES	SCOPE	SPECIFIC OBJECTIVES	RISK CRITERIA
					Function of:
PUBLIC WATER SUPPLY	VITENS (Public Water Supply utility)	Assure efficient production of drinking water in climate change scenarios	**Service continuity**: Water provision for public water supply and for other consumers (industry)	Assure sufficient **volumes** of water supply during 365 days/year for drinking water and all industrial costumers	**Number of minute**s in daily average flow with no supply
			Reputation: Vitens	Keep and improve positive **image** of sustainable and environmental friendly company	**No. of reports** in public media with critics or bad reputation

4.3.3 Establishment of the external context

In the Table 4.4, the PESTLE approach is again applied, but now to establish the external context Vitens with respect to its responsibility of securing an efficient production of drinking water in different climate change scenario's. Part of this external context overlaps with that of the province.

Table 4.4: Veluwe RS - External context for the RMP of Vitens (PWS)

PESTLE dimension	RS KEY ISSUES	LIST
POLITICAL	EU policies	Recurrent discussions on European policy in the direction of the privatization of public water supply across Europe
	Policies on groundwater protection	Changing policies on groundwater protection; the national government has recently initiated an exploration into "strategic" groundwater reserves that should be protected to ensure future water demands. The Veluwe is part of this exploration.
	Governance structure	The division of responsibilities between state, province, water board and drinking water company for water resource management will probably remain the same (no changes foreseen). However, in the governance field of spatial planning, responsibilities are currently shifting more to the local level as a result of new legislation (De Omgevingswet). These changes may impact on Vitens as under the new law, municipalities will have more autonomy in drafting land-use plans and deciding on which activities are and are not allowed.
ECONOMIC	Development in national and regional economy	New investment budgets of the European Investment Bank to increase international collaboration and assistance in the public water supply sector. Development of national economy: increase in water use. Development in regional economic and tourism sector: increase in pressure on Veluwe.
SOCIAL	Changes in attitudes	An increased awareness about the water services dependent on the Veluwe ecosystem can help manage the quality of groundwater resources.
TECHNOLOGICAL	Sustainable technologies	Development of sustainable technological solutions for quality monitoring, drinking water treatment and purification.
LEGAL	Legal framework	The following laws are important to Vitens: the EU Water Framework Directive (2000/60/EG) and its Groundwater Directive, the Dutch Drinking Water Law and its Drinking Water Decree (July 2009), Provincial and municipal spatial planning regulations (July 2015), the national-level policy on strategic groundwater resources (2015).
ENVIRONMENTAL	Land use	Change in land use due to new policies on groundwater protection or new economic activity (these changes are connected to the decentralization of responsibilities for spatial planning).

4.3.4 Establishment of the internal context

Internal structure

Vitens employs over 1.400 people. The internal management is guided by a board of directors.

Resources

Drinking water companies in the Netherlands emerged as technocratic management organizations; their sole focus lay on water quality and infrastructure management, with cost-efficiency being a top priority. And up to today, these are still strong characteristics of drinking water companies. Vitens is an important supplier of knowledge and expertise on underground coordination of water resources and water quality. Also, the company is renowned for its effective control of the costs involved with the supply of drinking water.

Internal culture

However, drinking water companies like Vitens increasingly operate in a space where a lot of other actors also place claims on land. These claims, furthermore, increasingly conflict as room becomes scarce in the densely planned Dutch landscape. In this new governance context, stakeholders require of Vitens to act more openly and transparently, and give public account of its actions. In reaction to these changes, Vitens is transforming its internal culture from a technocratic company to a more open organization that interacts with stakeholders, listens to their concerns and needs, and is open to finding win-win solutions.

Existing practices and future strategies

As a result of this changing internal culture, existing routines and practices of Vitens have evolved as well. While it continues to apply the necessary technical and financial know-how to manage its assets and supply, Vitens increasingly takes a position in area-based planning processes where different stakeholders in an area together try to find solutions for a sustainable and equitable layout of the area in which different functions have been attuned to each other as effectively as possible.

Whether these new strategies will be effective (metrics for success) will be tested against the risk criteria formulated in Table 4.3

5 RMP CONTEXT AT TROODOS RESEARCH SITE

5.1. Identification of the risk management processes at the Troodos Research Site

The Cyprus Research Site is located along the northern slopes of the Troodos Mountains in Cyprus. The Troodos Mountains form the "water tower" of the island, with many streams running down its steep slopes, in deeply incised valleys. The northern slopes are in the rain shadow of the mountains and are less endowed with water resources than the southern slopes. Investigations in the agro-ecological and hydrological processes along the northern slopes of the Troodos could also present insights into the potential effects of climate change on the southern slopes.

Two representative watersheds were selected in the Northern Troodos Research Site for the BINGO research: the **Peristerona Watershed** (112 km^2) and the **Pedieos Watershed** (120 km^2). Both rivers flow across the buffer zone into the northern part of the island, inhabited by the Turkish Cypriot community (Figure 5.1). Three different climate change adaptation cases will be studied in these two watersheds.

The main objective of the research in **Peristerona Watershed** is to develop strategies for climate change adaptation for two main water uses, namely agriculture and domestic water supply, based on increased scientific knowledge of the hydrological processes in the upstream area**. Risk management** research will be conducted with the rural communities in the downstream area, who depend on the water resources that originate upstream. The first system concerns **agriculture**, which is the most relevant activity in the region. The second system is **domestic water supply** in these rural communities. In the case of agriculture, irrigation associations are the risk owner under low precipitation and droughts. For the domestic water supply, community councils are the risk owner under low precipitation and droughts. The full extent of the Risk Management Process (risk assessment and treatment) will be established for these two interlinked systems.

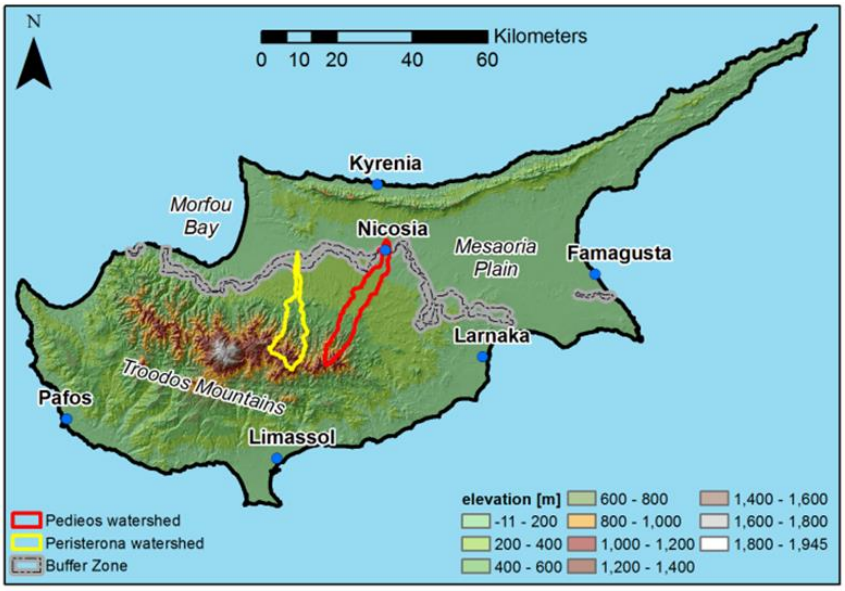


Figure 5.1: The Troodos mountains in Cyprus with the Peristerona and Pedieos Watersheds along the northern slopes

The third system is located in the **Pedieos Watershed**. In the Pedieos Watershed we will define the flood hazards under climate change (WP3) and a list of risk adaptation measures will be developed (WP5). **No risk analysis will be conducted**.

5.2. Agriculture – Irrigation Associations, Peristerona Watershed

5.2.1 Risk approach within BINGO

5.2.1.1. Adaptation objectives within BINGO

The BINGO objective is to develop strategies for climate change adaptation for the most relevant economic activity in the region, i.e., agriculture, especially under low precipitation and drought conditions. More precisely, the adaptation objectives are to match water demand (mainly groundwater) with available supply and to reduce water losses. These strategies will ensure fair, efficient and sustainable management of irrigation water supply.

5.2.1.2. Research site description

The Peristerona River flows from the northern flank of the Troodos Mountains into the Mesaoria Plain (Figure 5.2). The climate along the northern slopes of Troodos is classified as semi-arid, while the mountains at higher elevations are classified as dry sub-humid (Bruggeman et al., 2015), according to the UNEP definition (Middleton and Thomas, 1997). The long-term average annual precipitation (1980-2010) was 754 mm at Polystypos (1100 m above sea level/asl) in the mountains of the Peristerona

Watershed. In the foothills, precipitation was 405 mm at Panagia Bridge (440 m asl), and 270 mm at Peristerona (200 m asl) in the plain. The lowest annual rainfall in Peristerona in the 30 year record, observed during the 2007-08 hydrologic year, was 126 mm, followed by 138 mm (1990-91). Daily rainfall maxima during the 30 year period were 139 mm in Polystipos (2 December 2001), 157 mm in Panagia Bridge and 100 mm in Peristerona, both on 18 January 2010.

The long-term (1980-2010) average monthly daily minimum temperatures in January (coldest month) were 3 ^{0}C in the mountains in Agros (1015 m asl) and 16 ^{0}C in Astromeritis (200 m asl) in the plain. The average daily maximum temperatures in July and August were 31 ^{0}C in Agros and 35 ^{0}C in Astromeritis. Average annual reference evapotranspiration, computed with the FAO Penman-Monteith equation (Allen et al., 1998), was 1278 mm in the mountains (Agros) and 1290 mm in the plain (Astromeritis).

In the upstream and midstream areas of the Peristerona Watershed the geology is dominated by the diabase and basal group formations, intrusive rocks of the Troodos ophiolitic sequence that form a heterogeneous fractured aquifer system (Mederer, 2009). In the upstream areas we also find gabbros and plagiogranates (plutonic rocks) with relatively high hydraulic conductivities. The Troodos foothills correspond to the transition area between the fractured diabase and basal group formations and the overlying, impermeable pillow lavas of the ophiolitic sequence. In the Mesaoria plain, the geology of the river narrow valley mainly consists of river alluvium, which overlays the Pleistocene member of the Circum Troodos sedimentary basin. This member is formed by marl grading upward into clays, silt, sandstone and gravel.

Figure 5.2: Google Earth image (4 April 2015) of the Peristerona Watershed (green), Panagia Bridge Station (light blue), community boundaries (pink), the UN buffer zone (red) and the research focus area (yellow). The map is oriented with North to the right

The Peristerona River is an ephemeral stream, which does not flow in summer. Surface runoff is highly variable. The average long-term annual stream flow at Panagia Bridge station in the foothills of Peristerona Watershed is 11.75 Mm^3 (1980-2010). Lowest annual flow was 1.85 Mm^3 (2008) and the maximum was 25.94 Mm^3 (2002). Total monthly flows for these years are presented in Figure 5.3.

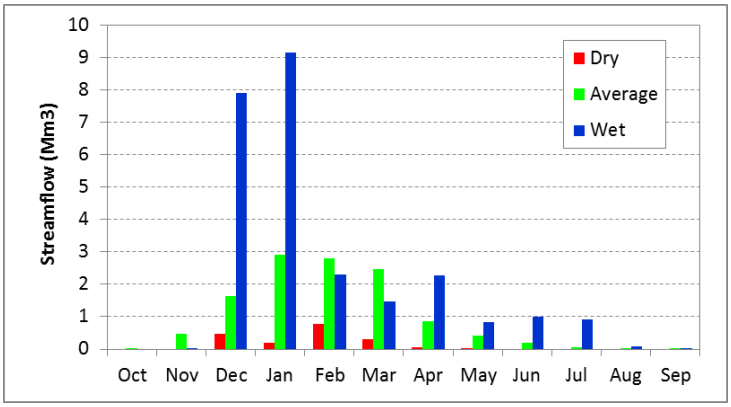


Figure 5.3: Total monthly streamflow at Panagia Bridge Station in Peristerona Watershed, driest (2007-2008) and wettest hydrologic year (2001-2002) and longterm average (1980-2010)

The streamflows from the Troodos recharge the groundwater formations in the Mesaoria Plain. Gabion check dams have been established across the riverbed to slow the stream flow and increase groundwater recharge in the downstream areas of the watershed. The downstream area of the Peristerona Watershed has been declared a nitrate vulnerable area (MANRE, 2012). High nitrate concentrations have been observed in boreholes in the downstream area. Levels in excess of 50 ppm have been found in one of the boreholes. Intensive pig farms in the river valley most likely contribute to the high nitrate levels. In addition, up to recently the area did not have a domestic sewage network.

In the upstream area of Peristerona Watershed we find sclerophylous vegetation, especially the Cyprus golden oak (Quercus alnifolia). These trees contribute to soil stabilization and prevent soil erosion due to their ability to colonize steep rocky hills (Loizides, 2011). The fractured volcanic formations in the steep sloping midstream areas are covered by state forests, which are dominated by Pinus brutia trees. This area forms part of the Adelphi forest, a Natura2000 site. Livestock grazing in state forests has been banned since British colonial rule in the late 19th century (Butzer and Harris, 2007). In the upstream and midstream areas of Peristerona Watershed agricultural lands are often located on terraces next to the streams, while the forested areas covers the steeper slopes above these lands.

According to the Census of Agriculture (Cystat, 2014a), agricultural cropland, including fallow, in the Peristerona Watershed's communities covered 3273 ha in 2010. In 2013, lands in good agricultural conditions, which were submitted and qualified for Single Area Payment support, totalled 3546 ha (Cyprus Agricultural Payment Organization datasets). In the upstream areas the main crop is wine grapes, followed by almonds. Almost all crops are grown on dry stone wall bench terraces. However, the wine grapes are also grown on broader sloping terraces with shallow soils. The area covered with almonds and hazelnuts is much larger than the listed 118 ha, but many of these trees are no longer harvested and maintained.

In the foothills and downstream, we find both rainfed and irrigated crops. Cereals, especially barley, are the main rainfed crop. Barley is generally grown for animal feed and often harvested and bailed whole, especially in dry years. Irrigated crops are found on small fields and terraces along the river (olives, vegetables), especially in Agia Marina and in the plain downstream from Peristerona community.

Average agricultural water demand in the upstream communities, including Agia Marina, is approximately 2 Mm^3, while it is almost 7 Mm^3 in the downstream communities (Bruggeman *et al.*, 2015). Throughout the watershed there are diversions from the stream, which supply irrigation water to the fields by gravity through a system of open channels. Groundwater pumping is also common, especially in the alluvial river aquifer. Agricultural water demand exceeds sustainable supply, especially in dry years (Zoumides *et al.*, 2013). Streamflow does not reach the downstream communities during dry years.

The research system is defined by the boundaries of the downstream communities of Kato Moni, Orounda, Peristerona and Astromeritis. The community of Astromeritis lies outside the watershed boundaries but receives irrigation water, diverted through open canals, from the Peristerona River. The downstream area of the Peristerona Watershed is very narrow, but the land of the communities also contains the neighbouring areas that are not connected to an upstream river. These communities use the surface and groundwater for irrigation that originates from the Peristerona River; groundwater is also the only source for domestic water supply (see section below).

5.2.1.3. Identification of risk owner and key stakeholders

The risk owner for the agricultural sector of Peristerona Watershed are the Irrigation associations and divisions of the downstream communities, namely Kato Moni, Orounda, Peristerona and Astromeritis.

The following key stakeholders have been identified:

- Farmers (external)
- Geological Survey Department (external)
- Water Development Department (external)
- Department of Agriculture (external)
- District Office (external)
- Community Councils (external)
- The Cyprus Institute (external)
- IACO Ltd (external)

5.2.1.4. Risk objectives, scope and criteria to evaluate the risk

The main risk scope of irrigation associations refers to water quantity (availability). The objectives and the criteria to evaluate the risks reflect the state of knowledge at the beginning of the project and it must be expected that they may change during the working time, because of the increase of knowledge and the intensification of cooperation with stakeholders. A first attempt of establishing those parameters to the risk for irrigation associations are summarized in the Table 5.1.

Table 5.1: Troodos RS - Objectives and scopes of the risk assessment processes of the Irrigation Associations

RISK OWNER	OBJECTIVE	SCOPE	SPECIFIC OBJECTIVES	RISK CRITERIA: Function of
Irrigation water users	Ensure fair, efficient and sustainable management of irrigation water supply	Ensure **sufficient irrigation water** for irrigated agriculture	**Match demand with sustainable supply**	**Volume: %** (Volume supplied)/ (Volume requested)
		Maintenance of infrastructure (pumps, pipes, concrete channels)	Reduce **water losses**	**Volume: %** Water use at field / water abstracted

5.2.2 Establishing the external context

The Pestle approach used to establish the external context of irrigation associations is presented in the Table 5.2.

Table 5.2: Troodos RS - External context for the RMP of the Irrigation Associations

PESTLE dimension	RS KEY ISSUES	LIST
POLITICAL	Compliance with EU and National political decisions	Common Agricultural Policy measures provide incentives for the adoption of water saving technologies. The Code of Good Agricultural Practices promotes the rational use of irrigation water. The pricing of water under the Water Framework Directive requirements affects the demand of irrigation water, although full cost recovery is not yet implemented in the irrigation section. In the new Rural Development Plan (2014-2020) any farmer that will not comply with environmental policies and good agricultural practices will not be eligible for receiving subsidies. Although irrigation water is managed by farmers within the association, any important political decision regarding agriculture affects farming operations.
ECONOMIC	Economic development	Agricultural land has decreased due to market pressures; people shift to non-farm activities
	Funding mechanisms	Economic development of Cyprus affects the funds allocated to the maintenance of distribution networks. Irrigation associations are small entities of 10 or more famers and are not eligible for funding through EU structural/cohesion funds. Each irrigation association is managing its own accounts by receiving water bills from irrigation users. Prior to Cyprus' accession to the EU, the government was financially supporting irrigation association in establishing and maintaining the irrigation networks (pumps, pipe network). These funds are not available any more, as it is seen as double funding (farmers are already subsidised through the Rural Development Programme). Many irrigation associations terminated their operations due to the termination of financial support by the government and the insufficiency of funds to maintain the irrigation network. Some irrigation associations, however, with better management approaches (e.g. timely collection of water bills and re-investment in the irrigation network) and have main their operation.
	Energy prices	The irrigation associations use electrical pumps to extract groundwater, therefore any changes in energy prices will affect the cost of irrigation. In fact, irrigation water supply is not charged by volume, but rather by time according to the electricity cost to operate the groundwater pumps. In the past, irrigation associations were receiving a reduced (subsidised) electricity prices, but not anymore, as irrigation associations are considered private entities.

PESTLE dimension	RS KEY ISSUES	LIST
SOCIAL	Population size/demographics	Ageing farm population
	Farm education	Low level of trained farmers
	Migration	Rural depopulation and migration to urban areas
TECHNOLOGICAL	Infrastructure development	Irrigation association managers are farmers and there is lack of technological knowledge. Farmers often seek for advice from extension services (Department of Agriculture).
	Technology development	Lack of training and providers of modern irrigation scheduling technologies (e.g., wireless sensor networks, apps).
LEGAL	Regulation and legislation (EU and national)	The implementation of EU Directives, such as the Water Framework Directive, the Nitrate Directive and Urban Waste Water Directive, is expected to improve the quality of the water resources. These Directives have been transposed to national legal system**.** Irrigation associations operate under a specific national law, according to which any group of 10 or more landowners can form an association and share amongst themselves the resources and the cost of water supply. Each association is governed by a committee which is chaired and checked by a District Administration (government) officer. The committee assigns book-keeping responsibilities to one farmer (collection of water bills), while the government officer audits the accounts of the association and checks that decisions comply with existing laws. For instance, under current policy changes, prior to drilling a new borehole, a permission is required by the Water Development Department.
ENVIRONMENTAL	Water quantity	Irrigation water use is determined by the availability of water resources. The water resources downstream are affected by upstream water use.
	Water quality	Overexploitation of aquifers deteriorates the quality of groundwater for irrigation. Intense use of agrochemicals and intensive livestock farms affects the quality of surface water for irrigation (eutrophication). The effect of groundwater pollution from agrochemicals, livestock farms and sewage pits on irrigation is not known.
	Climate Change	Higher temperatures and lower precipitation affect the crop water requirements and the available water for irrigation.
	Land use change and crop diversification	The changes in agricultural land use and the diversification of crops affect irrigation water use.

5.2.3 Establishing the internal context

a) GOVERNANCE & STAKEHOLDERS

Irrigation associations are formed by seven or more private land users that are entitled an 'ab antiquo' right to use water resources for irrigation purposes. The associations draw up their own rules and are administered by a committee under the chairmanship of the District Officer. Owners of rights to water sources do not have to use the water for irrigation if the management committee decides otherwise. Many proprietors sell or lease their share of water to other landowners for irrigation.

Irrigation Divisions can be formed by 10 or more land owners in order to share the water resources and the cost of supply, following an agreement. Water supplied usually originate from boreholes or river diversions; the Government has supported financially the establishment of water supply infrastructure (pipes, canals etc.) through loans and costs subsidisation. The Irrigation Division has a management committee chaired by the District Officer and the President of the community. The committee is responsible for balancing its own finances and recovers its costs from the water users (individual members).

b) GOALS & OBJECTIVES

The main objective of the irrigation associations is to ensure sufficient amount of water for farmers, and to maintain the irrigation supply system in good condition.

c) STRATEGIES

The allocation of water among the members of the associations is determined by the extent of cultivated area and the crops grown. During drought periods, irrigation is supplied in lower quantities due to reduced availability. The Water Development Department issues the water rationing measures.

d) RESOURCES

The associations' resources include basic technology and equipment (motor and pipes). The funding and the operation of the associations is internally managed by its members. There is no existing risk management expertise and practice, although in dry periods water rationing measures apply.

e) INTERNAL CULTURE

Irrigation association do not have an adaptation strategy to climate change. Although some of the irrigation users acknowledge climate change risks, there is substantial resistance to change practices.

5.3. Domestic water supply – Community Councils, Peristerona Watershed

5.3.1 Risk approach within BINGO

5.3.1.1. Adaptation objectives within BINGO

The BINGO climate change objective is to develop strategies for climate change adaptation that manage the risk of water supply continuity failure due to insufficient water availability caused by abstraction of water resources (groundwater) and the water quality degradation caused by pollution and climate change impacts.

5.3.1.2. Research site description

See section 5.2.1.2 for the biophysical description of the research site.

The communities in the Peristerona Watershed rely on groundwater for domestic water supply. The permanent population in the communities in the upstream area, including Agia Marina, totals 1167, while the population of the downstream communities numbers 5476 (Cystat, 2014b). Within BINGO, risk management for domestic water supply focuses on the downstream communities (Kato Moni, Orounda, Peristerona) due the larger population share. Domestic water supply is managed by Community Councils. The councils are legally responsible for selling and servicing water supply to households through the Communities Law 86(1), which fall under the authority of a central water management authority: the Water Development Department (WDD). The pricing structure is approved and groundwater exploitation is overseen. Quality checks are performed by the national government's Public Health Services Department of the Ministry of Health and communal groundwater extraction policies are supported by its Geological Survey Department.

Day-to-day management practices for domestic supply are largely based on empirical knowledge. This means that there is no structure to ensure that knowledge about the possible long-term impacts of climate change is taken into account in actual water management practices. Also, there is no leak-detection system, partly because this requires high investment costs.

5.3.1.3. Identification of risk owner and key stakeholders

The identified risk owner for the domestic water supply sector of Peristerona watershed are the Community Councils of downstream areas.

The following key stakeholders have been identified:

- Rural households (external)
- Geological Survey Department (external)
- Water Development Department (external)
- The Cyprus Institute (external)
- IACO Ltd (external)

5.3.1.4. Risk objectives, scope and criteria to evaluate the risk

The main risk scope of Community Councils are the following:

- Continuity of water supply
- Good quality of drinking water

The objectives and the criteria to evaluate the risks reflect the state of knowledge at the beginning of the project and it must be expected that they may change during the working time, because of the increase of knowledge and the intensification of cooperation with stakeholders. A first attempt of establishing those parameters to the risk for community councils are summarized in the Table 5.3.

Table 5.3 : Troodos RS - Objectives and scopes of the risk assessment processes of the Community Councils

RISK OWNER	OBJECTIVE	SCOPE	SPECIFIC OBJECTIVES	RISK CRITERIA: Function of
Community councils	Supply drinking water to community households	Ensure **Continuity of water supply**	To supply water in adequate quantity and at affordable cost	Groundwater yield (m3/hour) and volume consumed (e.g. l/cap/day)
			To supply water with adequate quality (i.e., that it will not harm customers' health)	EU drinking water quality standards

5.3.2 Establishing the external context

The Pestle approach used to establish the external context of the community councils is presented in the Table 5.4.

Table 5.4: Troodos RS - External context for the RMP of the Community Councils

PESTLE dimension	RS KEY ISSUES	LIST
POLITICAL	Compliance with EU and National political decisions	The implementation of EU Directives, such as the Water Framework, Nitrate Directive and Urban Waste Water Directive, is expected to improve the quality of water resources. Each community council is responsible for managing and providing (selling) water supply to household, as part of their municipal works organisation. The regulatory authority for water management is the governmental Water Development Department. Water quality checks are performed at least once a month by Public Health Services. Water supply to households is metered and is charged according to the volume consumed. The water charges of each community council are reported annually to the District Administration and are approved by the Water Development Department; the price of water should recover all cost, i.e., financial, environmental and resource cost.
ECONOMIC	Funding mechanisms	Cyprus economic development affects the funds allocated to local communities. Due to their size, individual communities are not able to apply for EU funding, but they can do so as clusters of communities. For day-to-day operations and maintenance of the supply network, communities use the funds raised from water bills. For more advanced maintenance (e.g. replacing the pipe network), the communities receive support from the government, as domestic water supply is considered of high priority and is associated with health issues.
	Energy cost	Energy prices affect the water supply cost as community councils use electrical pumps to extract and supply groundwater to households. Therefore any changes in energy prices will affect the cost of irrigation.
SOCIAL	Population size/demographics	Population changes affect water demand; increase in population implies increase in water demand and thus further investments on water supply systems
	Consumption patterns and lifestyle	Water consumption patterns are affected by the lifestyle and culture of individuals. In general, modern societies tend to consume more water within the household than the previous generation.
	Education	Better education results in adopting more environmental friendly practices. According to the Water Development Department, awareness campaigns and education of young students have been very effective as regards water conservation at the household level.

PESTLE dimension	RS KEY ISSUES	LIST
TECHNOLOGICAL	Infrastructure development	Development of new infrastructure to improve water management. Assistance is provided by the Geological Survey Department for the development of new boreholes for domestic water supply.
	Technology development	Potential opportunities as a result of technological development and its implications in water management. In general, there are more leakages in the water supply network of communities than in the urban centres.
LEGAL	Regulation and legislation (EU and national)	National and European water related legislation, e.g., Water Framework Directive, Drinking Water Directive determine the operational context of water supply institutions.
ENVIRONMENTAL	Water quantity	Water variability affects the available water for domestic use. The majority of domestic water supply relies on groundwater; the performance of boreholes (m^3/hour) decreases substantially in dry years
	Water quality	The region is susceptible to nitrate pollution from agrochemical leaching and livestock waste, which affects the quality of water. During drought periods, the quality of water resources is negatively affected.
	Climate Change	Higher temperatures as well as lower and more extreme precipitation patterns affect water supply in the region. Higher temperatures imply higher demand for domestic water. Higher variability in the available water resources affects the pressure of the supply systems which can create problems in the network and increasing the cost of maintenance and operation.
	Land use change	The changes in land use affect the water supply in the region.

5.3.3 Establishing the internal context

a) GOVERNANCE & STAKEHOLDERS

Domestic water supply is managed by the local community councils (risk owners). The downstream communities rely exclusively on groundwater for domestic water supply. The Geological Survey Department is responsible for monitoring the water quality. This Department also provides assistance to Community Councils in developing new boreholes.

b) GOALS & OBJECTIVES

The main objective of the community councils is to ensure a sufficient amount of water of good quality and to provide continual water supply to rural households for domestic use.

c) STRATEGIES

In extreme dry years, water supply measures are imposed (e.g. restriction on water supply). One community applies a quota system (predefined volume of water per person per day). In general, most communities have multiple boreholes to provide water for domestic use. Only one community relies on a single borehole which implies higher risks in terms of domestic supply. The Community Councils can impose fines for wasteful use of water resources, i.e. when households exceed predefined volume of water.

d) RESOURCES

The Water Development Department provides assistance to Community Councils regarding the distribution networks (there is no technical staff in the Community Councils). The domestic water quality is regularly monitored by the Geological Survey Department. Water supply to households is metered and charged accordingly to recover the operation cost.

e) INTERNAL CULTURE

Community councils are concerned by the climate change risks in terms of domestic water supply and urge households towards rational domestic water use. In general, they are willing to adapt to climate change challenges and there is interest in scientific support.

5.4. Flooding, Pedieos Watershed

5.4.1 Pedieos Watershed Objective within BINGO

The BINGO objective in the Pedieos Watershed is to conduct flood hazard analysis, under climate and land use change. The research will also include a list of potential structural and non-structural adaptation measures. **No risk assessment will be conducted for the Pedieos Watershed system**.

5.4.2 System characterization

The long-term average annual precipitation (1980-2010) in the upstream areas of the Pedieos Watershed was 670 mm at Kionia (1200 m asl), while in the foothills, it was 344 mm in Politiko (405 m asl) and 306 mm in Nicosia (160 m asl) in the plains. Average annual reference evapotranspiration, computed with the FAO Penman-Monteith equation (Allen et al., 1998), was 1384 mm in Nicosia in the plains. Daily rainfall maxima during the period 1980-2010 were 196 mm in Kionia on 2 December 2001. Average monthly daily minimum temperatures were 6 ^{0}C in Nicosia, during January, while the daily maximum temperatures were 37 ^{0}C in Nicosia, in July and August (1980-2010).

In the upstream and midstream areas of the Pedieos Watershed the geology is dominated by the diabase and basal group formations, intrusive rocks of the Troodos ophiolitic sequence that form a heterogeneous fractured aquifer system (Mederer, 2009). The Troodos foothills correspond to the transition area between the fractured diabase and basal group formations and the overlying, impermeable pillow lavas of the ophiolitic sequence. The Mesaoria aquifers in the plain are sedimentary formations, consisting of siltstones, calcarenites and marls (Nicosia formation) followed by the clastic deposits (gravels, sand and silt) of the Pleistone fanglomerate formation. These formations are overlain by the alluvium of the river valleys. The Pedieos River is an ephemeral stream, which does not flow in summer.

The streamflows from the Troodos recharge the groundwater formations in the Mesaoria Plain. Gabion check dams have been established across the riverbed to slow the stream flow and increase groundwater recharge in the downstream areas of the watershed.

Streamflow is monitored by the Cyprus Water Development Department at two stations just upstream from the Tamassos dam. However, the weir at the western river branch is submerged when the dam reservoir is full and operation stopped in September 2001.

Total annual flows of the two branches for the period 1982-2001 ranged between 0.95 Mm^3 (1998) and 12.87 Mm^3 (1992). The largest event in the past 40 years produced 3.1 Mm^3 of water in one day. This event occurred on 9 January 1989 and resulted from 57 mm rain over the upstream catchment on the preceding day and 108 mm on the day itself. Considering that there is always water in the reservoir in winter time, an enormous volume of water would have flown through the spillway of the dam.

The upstream area of the Pedieos Watershed is covered by Pinus brutia forests. This area is known as the Maheras Forest, an important Natura 2000 site (Department of Forestry, 2012). Smaller areas of sclerophyllous and shrub woodlands and few plots of rain-fed cereals, irrigated fruit trees, greenhouses and livestock farms are also found in the upstream area. At the bottom of the foothills, the Tamassos dam captures and stores the runoff of the 45-km2 upstream river basin in a 2.8-million m^3 reservoir. About half a dozen rural communities are located in the plains, downstream of the dam. Here barley, olives and irrigated vegetables are the most common crops. The river then flows into the urban agglomeration of the capital Nicosia and its adjacent municipalities (see Figure 5.4).

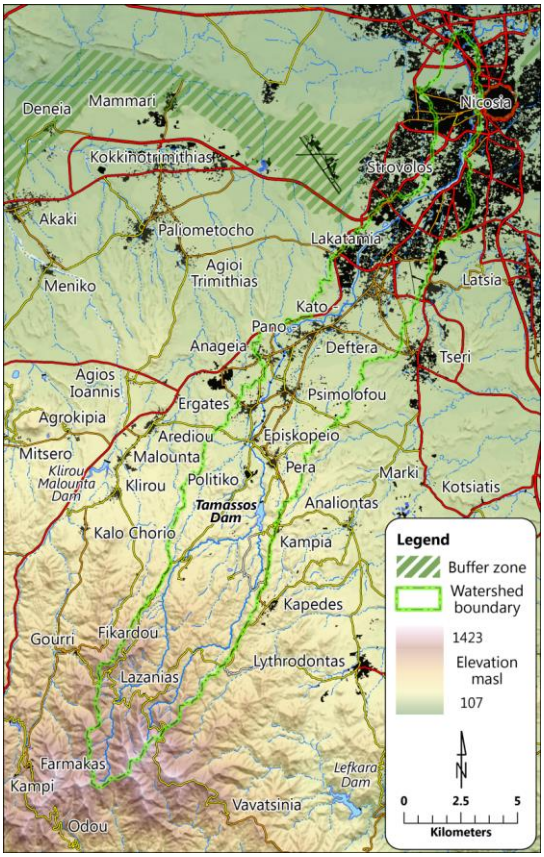


Figure 5.4: Map of the Pedieos Watershed

The rural communities of Kampia, Psimolofou and Episkopio (and Kapedes, just outside the watershed) receive water from the Tamassos dam reservoir (interview with Pera Community leader, March 2014). Anthoupolis, Deftera and Ergates receive water from the seawater desalination plants supplied by the Nicosia Water Board (interview with Deftera Community Leaders, March 2014; Director of Nicosia Water Board, Cyprus Mail, 2013). However, some of the rural communities also pump groundwater for their domestic supply. The urban communities receive their water supply from the Nicosia Water Board. The water is predominantly sourced from the seawater desalination plants outside the basin, through the southern conveyor system. Irrigation is the largest user of water in the rural areas of Pedieos consuming on average 4.5 Mm^3/year (82%). Most irrigation water is pumped from groundwater. Treated sewage water from the Anthopouli Treatment plant is also used for irrigation in some of the downstream areas.

The history of flooding from the Pedieos River in the urban areas of Nicosia has been investigated by Charalambous *et al.* (in review). Historical records showed that responses to floods ranged from prayers and other religious rituals in the 14th century to stormwater drainage networks and dam construction in the 20th and 21st century.

I.A.C.O, 2006 conducted a flood modelling study for the design of the linear park and cycling path along the Pedieos River. The river segment where this linear park was envisioned, was found to have an active channel width of 25 m on average (10 – 40m), while lacking suitable adjacent flood plains due to housing development. However, the active channel was found to present enough depth on average, rendering it suitable to accommodate flows of low frequency. Certain road crossings, mainly due to their design characteristics, i.e. Irish bridges, were found to be susceptible to flooding in high frequency events. In general, and since the linear park could only be placed within the active channel's width, an elevated pathway and bicycle lane of at least 3m higher than the active channel's bed elevation was recommended in order to mitigate estimated flood risks.

The Tamassos dam, which was completed in 2002, provides flood protection in the Pedieos Basin, by capturing the water of the steeply sloping upstream areas. However, due to increasing urbanization, the downstream area is highly susceptible to floods. During heavy rainfall events runoff from the surrounding paved areas flows to the river. A total of 38 floods were recorded in urban Nicosia, from 1960 to 2012, of which three were caused by flooding from the river (I.A.C.O, 2011). Natural vegetation that grows in the dry river bed impedes the flow of the water. Garbage and branches that are

dragged along by the flood get trapped at the low road crossings over the river, causing water to spill over the road.

The Water Development Department has identified the urban area along the Pedieos as an area of potentially significant flood risk, for the European Flood Directive (2007/60/EC). Flood hazard and flood risk maps and a flood management plan have been prepared for the flood sensitive areas (WDD, 2015) of the Pedieos Watershed. The Flood Management Plan, which is currently under consultation, recommends the natural rehabilitation and improvement of waterways, including interventions to improve the hydraulic functioning of watercourses and to increase the discharge capacity. Alert mechanism for extreme weather and flooding (combination of thunderstorms and high reservoir level at Tamassos Dam) for the downstream Pedieos municipalities of Nicosia, Strovolos and Lakatamia are also suggested (WDD, 2015).

6 RMP CONTEXT AT TAGUS RESEARCH SITE

6.1. Identification of the risk management processes of Tagus RS

The Portuguese research site is located in the lower Tagus river basin. It addresses climate change adaptation of two key sectors, one concerning an important public service, water supply, and the other concerning agriculture, one of the most relevant economic activities in the region.

Being water the central resource in BINGO, the climate change adaptation concerns, essentially, how changes in water resources availability and quality compromises both sectors and how they should prepare themselves to deal with these changes.

Reduction in water availability and quality degradation, associated with more frequent and intense droughts, are the main concerns of both sectors but, in some specific cases, inundations are also of concern, essentially if they are due to storm surges in the estuary, or other events that increase the salt water intrusion in the water abstraction points or cause farming lands inundations with high salinity content.

The **public water supply sector** is represented in BINGO by EPAL, the oldest water company of Portugal that supplies Lisbon city and other surroundings 35 municipalities of the right margin of the river Tagus. EPAL doesn't hold private water sources. On the contrary, it has to share water resources with other users. EPAL BINGO climate change adaptation objective is to develop strategies to assure water supply continuity, in case of reduction of water availability or degradation of water quality caused by climate changes. Water resources governance is a key issue for EPAL.

The **agriculture sector** in Tagus RS is focused in two different cases of public irrigation perimeters (PIP) in the left lower margin of Tagus river: the **Sorraia Valley** and the **Lezíria Grande de Vila Franca de Xira** – LGVFX (hereinafter called "Lezíria Grande"). A third case relates to the farmers of the remaining lower Tagus (**Lezíria do Vale do Tejo – LVT**), will be analysed. As they do not benefit from public irrigation infrastructures they represent a distinct reality. Water resources governance related risks concerning those farmers will also be identified, in order to contribute to overall governance suggestions of improvement, to be developed in work package 5.

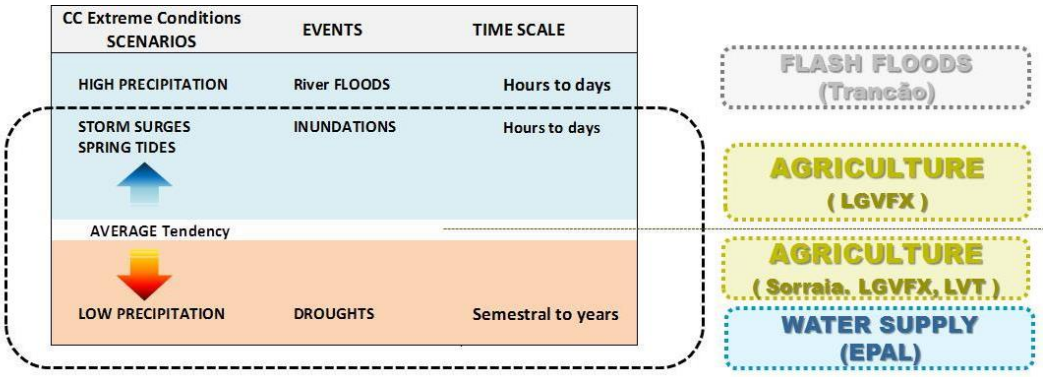
As far as the **agriculture sector** concerns, the main agriculture objective in BINGO is to strengthen this economic sector by developing strategies for climate change adaptation in the region under low precipitation (droughts) and to identify the risk

associated with estuarine inundation due to spring tides combined with storms surges and sea level rise scenarios. How governance can be improved to facilitate sectoral adaptation is a key issue to be addressed.

Other important water uses exist in the region, for example hydroelectric production and other public water supply entities both on the left and right Tagus margin. They all compete for the same limited water resources. Therefore, water resources governance is a key transversal issue of the Tagus research site climate change adaptation under low precipitation.

People safety and property protection against flash flooding is being addressed in Trancão river basin, an affluent of the Tagus river. The existing hazard to people and property will be estimated.

Figure 6.1 summarises the case studies being addressed in the Portuguese research site. The following subchapters will address the risk approach to be used to support later adaptation strategies definition.



Legend: EPAL Public Water Supply utility
LGVFX Lezíria Grande de Vila Franca de Xira
LVT Lezíria do Vale do Tejo

Figure 6.1: Case studies addressed in Tagus research site

In conclusion, the extend of the RMP for Trancão river floods and for Lezíria Grande PIP will be the three steps of CC risk assessment (risk identification, analysis and evaluation) and only a list of risk adaptation measures will be defined (in WP5). On the other hand, the full RMP (risk assessment and treatment) will be established for the EPAL PWS, for the Sorraia Valley PIP and for the farmers of Lezíria do Vale do Tejo.

The process will be done in close cooperation and co-production with these risk owners.

6.2. Public water supply - EPAL

6.2.1 *Risk approach within BINGO*

6.2.1.1. Adaptation objectives within BINGO

The BINGO climate change adaptation objective is to manage the risk of reduction of water production, due to insufficient water availability or quality, caused by storage depletion of water sources (superficial or groundwater) or quality degradation caused by climate change impacts in water resources. On EPAL's perspective, risks related to climate change are seen as truly strategic, given the fact that a range of consequences may arise from several risk categories, beside quality and quantity of water supplied, such as service reliability, business sustainability, profitability and reputation.

The aims are *(i)* to estimate if climate change will affect EPAL water supply sources, both in quantitative and qualitative terms, imposing restrictions on the public service and *(ii)* to identify to what extent the competition for the same resources by other entities, including the agriculture sector or the public supply to municipalities of the left bank of the Tagus River, will become a problem for local and strategic reserves of EPAL.

6.2.1.2. Characterization of the research site from the risk assessment point of view

a) General characterization

EPAL supplies drinking water to an area of 7,090 km^2, corresponding to 35 municipalities with a population of more than 2.9 million inhabitants, from which almost 500 thousand are inhabitants in Lisbon municipality (retail wholesale). The PWS has a nominal production capacity that can reach over 1,000,000 m^3/day.

The EPAL is responsible for water collection, treatment and transport to the company's customers and includes the production, the transport and the distribution systems. Note that BINGO RMP is focused only in the production and transport system, especially in the water sources and abstraction, therefore not including the water distribution. The main sub-systems associated with EPAL sources are (Figure 6.2):

- Castelo do Bode sub-system, based on a reservoir with the same name, located in the Zêzere River, built in 1987 and extended in 2007 (surface waters);
- Tagus (Tejo) sub-system, including Valada - Tejo surface water intake and Valadas underground waters, opened in 1940 and extended in 1963 and 1976;
- Alviela sub-system, which has been operating since 1880 but, nowadays, is not fully in operation, since the water intake in Alviela River and the upstream part of the aqueduct are no long in service.

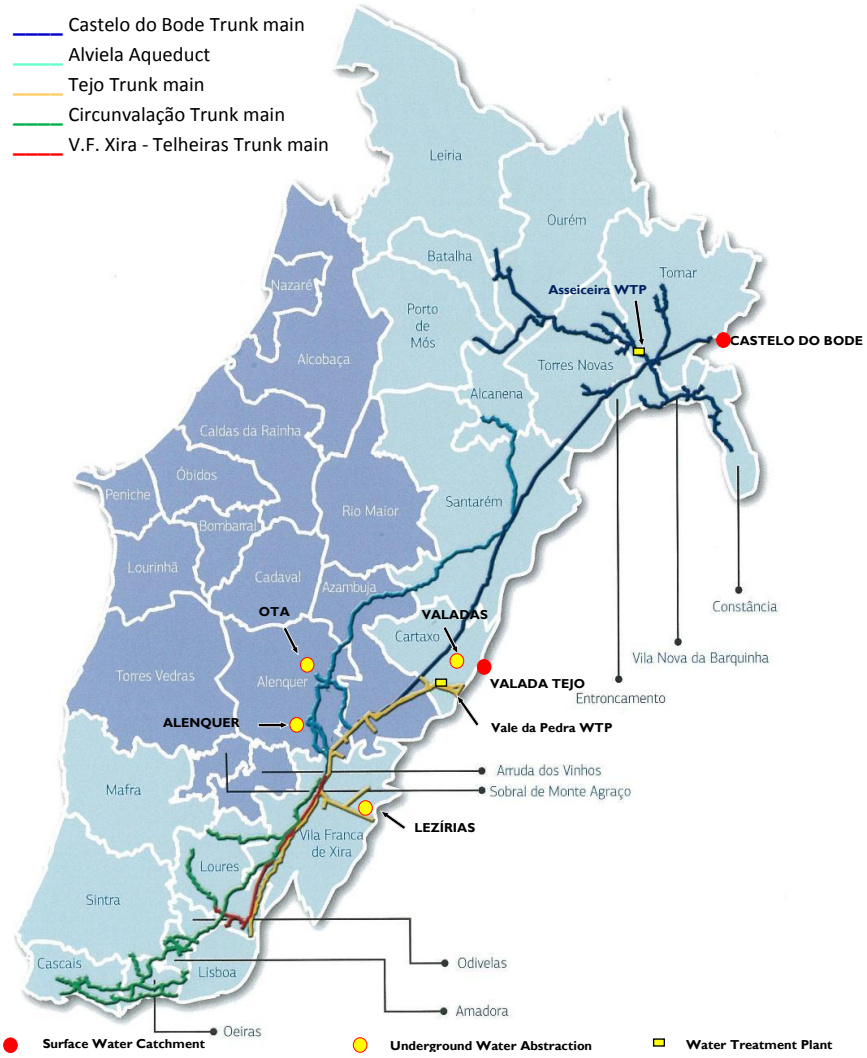


Figure 6.2: EPAL production & transport system and municipalities supplied.

The Castelo do Bode sub-system:

It includes the main water abstraction source of Castelo de Bode reservoir, accounting for more than 80% of the water supplied. It has a daily production capacity of

625,000 m³. The system includes a water collection tower located in the reservoir, the Pumping Stations I and II, downstream from the dam with the same name, the Asseiceira Water Treatment Plant (WTP) localized 9 km downstream of the pumping stations and 80 km of trunk mains that connect the WTP with the Vila Franca de Xira Pumping Station.

The Tagus sub-system:

The second largest system is the River Tagus system, which has a daily production capacity of 240,000 m³. It includes the following water sources:

- Valada water intake (surface water); located in Tagus upper transitional waters limit, is a secondary water source and contributes with 12 to 23% of the total volume supplied;
- Underground waters, with abstraction points in Valada (in the Tagus Alluvium) and in Lezíria (in the Tagus-Sado Aquifer ME-Left margin aquifer).

Alviela sub-system:

- Nowadays, this system includes only underground abstractions in the OTA-Alenquer aquifers.

Those three sub-systems include 2 surface collection points (Castelo do Bode and Valada water intake), 30 underground collection points and about 700 Km of trunk mains, 2 water treatment stations, 31 pumping stations, 28 water tanks, 19 chlorination posts and 125 delivery points. The operation is managed through a SCADA system (remote system), that is highly automated and centralises operation and control in real time of more than 170 facilities ranging from pumping stations to treatment stations, from reservoirs to valves.

Due to the enlargement of the EPAL system in 2007 and to the concomitant turn over-observed in the historical increasing demand, the water supply system now evidences an overcapacity of drinking water production and transport. The water supply system is very resilient to climate change, due to the fact that the main water source, the Castelo do Bode reservoir, presents an enormous storage capacity and is associated with an efficient treatment plant.

b) Water sources

The main water sources in the system are surface collection points – Castelo do Bode reservoir (Zêzere river) and, in the right bank of the Tagus river, Valada water intake; also there are underground sources located in Ota, Alenquer, Lezíria and Valada. All

the water sources are located in the Tagus River Basin, which is shared with Spain, although Zêzere river sub-basin is fully located in Portuguese territory (see red dots (superficial sources) and yellow dots (underground sources) in Figure 6.2).

Castelo do Bode reservoir:

The reservoir is located in the totally Portuguese Zêzere river sub-basin, 9 km upstream the Tagus river, and is shared with EDP (the Portuguese Company of Electricity) which owns the dam (Figure 6.3 a)). It has a daily production capacity of 625,000 m³. The water body of Castelo do Bode reservoir has good ecological and chemical quality.

Valada water intake:

The Valada water intake (surface water) is located in Tagus upper transitional waters limit, is a secondary water source and contributes with 12 to 23% of the total volume supplied (Figure 6.3 b)). The Valada water intake is one vulnerable point of the overall abstraction system. It is located in Tagus upper transitional waters limit and no saline intrusion is detected but the mechanical effect of tide is still evident. Presently this water abstraction is already operated according to tides. This water source is also very dependent of the discharges from dams located upstream (Castelo do Bode, and, especially, the dams located in Spanish Tagus river stretch) both in quantitative terms as well as in quality issues, as the water dilution they promote ameliorate water quality and reduce salinity. Note that one of the issues to be modelled in BINGO is checking if saltwater intrusion can compromise this water catchment.

Figure 6.3: EPAL's water surface sources: a) Castelo do Bode dam in Zêzere river (Tagus right margin tributary; b) Valada water intake in Tagus river.

Groundwater:

Table 6.1 presents a list of current EPAL underground sources and their contribution to the whole system. Some of the origins only count as strategic reserve, to be used in case of necessity; others have a fundamental role in the system with clients directly

dependent on their water and are used on a daily basis (function classified as “Principal”) and others although not indispensable are also used regularly (function classified as “Supplementary"). These underground sources account presently for less than 10% of water. The abstractions are in the Tagus-Sado aquifer (ME), in the Tagus alluvium and in the Ota- Alenquer aquifers. The main sources are the Tagus-Sado aquifer (ME), the Tagus alluvium and the Ota- Alenquer aquifers. The full physical characterization of those aquifers is presented in deliverable 3.1 (Alphen *et al*, 2016).

Table 6.1: EPAL’s underground abstractions

System	Subsystem	Abstraction Description	Main Features								Guaranteed production capacity
			Source	Type of abstraction	Number of wells	Wells description	Function in Supply System	Operational readiness	Nominal Capacity (m^3/day)	Resource type	Nominal (m^3/day)
Alviela	Alenquer	Alenquer	Karst Aquifer	Wells	3	P1	Principal	Operational (in service)	16 500	Guaranteed	43 000
						P2	Reserve	Operational (not in service)	20 000	Emergency	
						P3	Principal	Operational (in service)	6 500	Guaranteed	
					1	P4	Reserve	Operational (not in service)	-	-	-
	Ota	Ota	Karst Aquifer	Wells	3	P1	Reserve	Operational (not in service)	10 000	Emergency	28 500
						P2	Principal	Operational (in service)	12 000	Guaranteed	
						P3	Principal	Operational (in service)	6 500		
Tejo	Lezírias	Lezíria II (G1 to G5)	Deep Miocene	Wells	10	GI-P5	Suplementary	Operational (in service)	6 000	Guaranteed	80 000
						GI-P6	Suplementary	Operational (in service)	4 800		
						G2-P7	Suplementary	Operational (in service)	6 000		
						G2-P8	Suplementary	Operational (in service)	6 000		
						G3-P9	Suplementary	Operational (in service)	6 000		
						G3-P10	Suplementary	Operational (in service)	6 000		
						G4-P11	Suplementary	Operational (in service)	6 000		
						G4-P12	Suplementary	Operational (in service)	6 000		
						G5-P13	Suplementary	Operational (in service)	4 800		
						G5-P14	Suplementary	Operational (in service)	4 400		
		Lezíria III (G6 to G7)	Deep Miocene	Wells	4	G6-P15	Suplementary	Operational (in service)	6 000		
						G6-P16	Suplementary	Operational (in service)	6 000		
						G7-P17	Suplementary	Operational (in service)	6 000		
						G7-P18	Suplementary	Operational (in service)	6 000		
	Valadas	Valada I	Mudslides	Wells	4	G13	Reserve	Operational (not in service)	4 500	Emergency	30 800
						G16A	Reserve	Operational (not in service)	4 500		
						G18A	Reserve	Operational (not in service)	4 500		
						G18S	Reserve	Operational (not in service)	4 300		
			Deep Miocene	Wells	3	G19P	Reserve	Operational (not in service)	4 400		
						G20P	Reserve	Operational (not in service)	4 300		
						G21P	Reserve	Operational (not in service)	4 300		
		Valada III	Mudslides	Wells	1	P4	Reserve	Operational (not in service)	6 000	Emergency	6 000
				Total	30						228 300

The following Figure 6.4 is a map of the geographical distribution of EPAL underground origins.

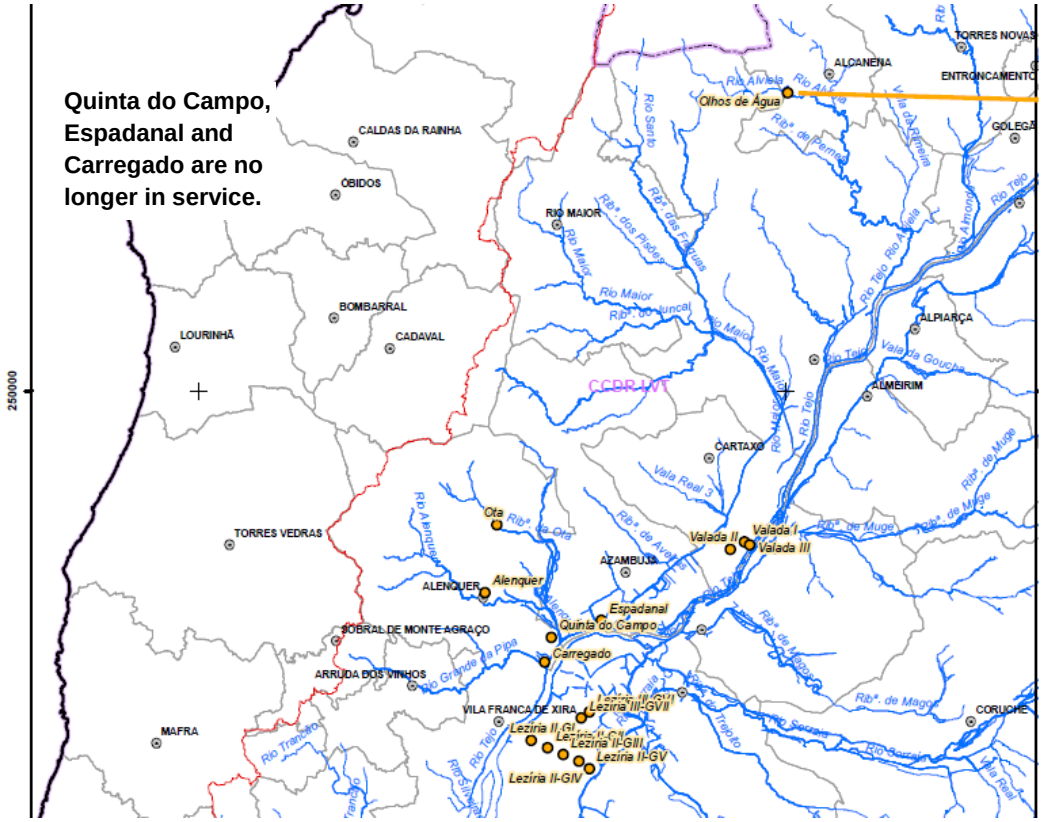


Figure 6.4: Geographic distribution of EPAL's underground abstractions (orange dots)

c) Water treatment

In the Castelo do Bode reservoir, the raw water – which is classified (according to the Portuguese legislation) as A1, i.e., of very good quality – is treated at Asseiceira WTP (Figure 6.5 a)), through a scheme comprising mineralization coagulation/flocculation, flotation, filtration and final disinfection (chlorine). Built in 1987 with the capacity to treat 500,000 m^3/day, this WTP was enlarged and modified in 2007 to treat 625,000 m^3/day.

Within the Tagus sub-system, the surface water of Valada intake is treated in the Vale da Pedra WTP, with a daily production capacity of 220,000 m^3 (Figure 6.5 b)). The water treatment includes pre-oxidation with ozone (after WTP refurbishment conclusion), conditioning of PH, coagulation/flocculation, decantation, filtration (one depth sand thickness), PH correction of the treated water and final disinfection, which allows to establish a chlorine residual in the drinking water (Figure 6.6). The lesser quality of the raw water abstracted in the Tagus River, together with the strengthening of rules on the quality of water for human consumption, led EPAL to invest in a major rehabilitation and reformulation of the treatment scheme in this WTP, currently in progress.

a) b)

Figure 6.5: EPAL's WTP: a) Asseiceira WTP in Zêzere sub-system; b) Vale da Pedra WTP in Tagus sub-system.

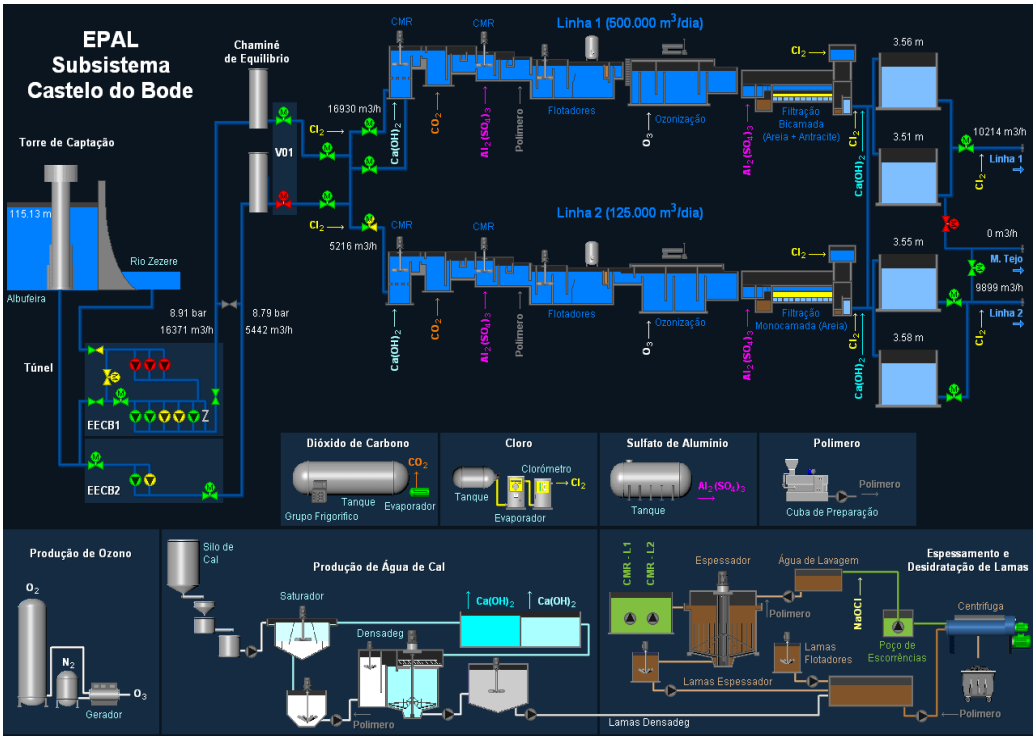


Figure 6.6: Synoptic flow diagram of Asseiceira WTP

In what concerns the underground abstractions in the Tagus sub-system, the water treatment is made by chlorine disinfection. In the Alviela sub-system, there is a station (Alenquer-Ota aquifer) where 7% of the abstracted raw water is decarbonized, by a process of ionic permutation, for PH adjustment of the raw water.

EPAL water quality in the sources is subject to an extensive control expressed in a sampling program which is agreed with the regulator on a yearly basis. The Water Quality Control Programme (WQCP) is ruled by the legal national instruments (Luís, 2014): Decree-Laws n.º 306/2007 and n.º 236/98. Luís (2014) describes the levels of compliance with the water quality laws, which in 2013 were as follows:

- Castelo do Bode reservoir: Class A2 for Fecal coliforms, Total coliforms, Dissolved hydrocarbons and Salmonella. Class A1 for all the other parameters.
- Tagus river at Valada: Class >A3 for Substances extractable with chloroform. Class A3 for Total coliforms and Salmonella. Class A2 for Fecal coliforms, Colour and Faecal streptococci. Class A1 for all the other parameters. Underground sources: Mineralized waters complying with class A1. The parameters Barium and Temperature at Lezírias abstraction exceeded the maximum admissible value for drinking water.

d) Transport system

EPAL Transport system has about 710 km of trunk mains, allowing for water transfers among them, strengthening the overall system (Figure 6.2).

Castelo do Bode sub-system:

The Castelo do Bode pipeline, begins in the reservoir with the same name, in the Zêzere river, and ends, 80 km downstream, in Vila Franca de Xira (VFX), where water is directly pumped to the VFX-Telheiras pipeline. This pipeline presents a diameter of 1500 m and has an extension of 26 km in its path to Lisbon, where it ends in Telheiras tank. A second main pipeline (designated “Circunvalação”) transports water from Vila Franca de Xira Pumping Station to the western municipalities in the Great Lisbon area (Amadora, Sintra, and Oeiras), being Cascais supplied by “Costa do Sol” main trunk, connected to “Circunvalação” in Oeiras. The Castelo do Bode sub-system can also receive underground waters from Valadas and its water can, as well, be transferred to the Tagus sub-system.

Tagus sub-system:

The Tagus Aqueduct is 49 km long. It begins in Azambuja and ends in the Olivais reservoir, in Lisbon. In Várzea das Chaminés, it receives water from the Vale da Pedra WTP, which comes from Valada surface water intake in the Tagus River. This water inflows through two main pipelines, with diameters of 1000 and 1250 mm. The Tagus Aqueduct also benefits from underground abstractions in Lezírias and, when necessary, from Castelo do Bode.

Alviela sub-system:

The Alviela Aqueduct is 120 km long, from the Olhos de Água spring to the Barbadinhos Water Tank, in Lisbon. This water infrastructure is not fully in operation (the abstraction and upstream part of it is out of service) but it continues to be used in

the water path to Lisbon and to delivery water to some municipalities. The Alviela sub-system benefits in a continuous way with water from the Castelo do Bode system, through a connection in Alcanhões, and with water from underground sources of Alenquer, Ota and Lezírias.

The Alviela sub-system can also receive water from the Tagus Aqueduct, downstream of VFX through Alhandra and Verdelha pumping stations. Other second connection with the Castelo do Bode sub-system is done upstream of VFX, through Pimenta Pumping Station.

6.2.1.3. Identification of risk owner and Key stakeholders

The risk owner is EPAL - Empresa Portuguesa das Águas Livres, S.A., the water company serving Lisbon and surrounding municipalities.

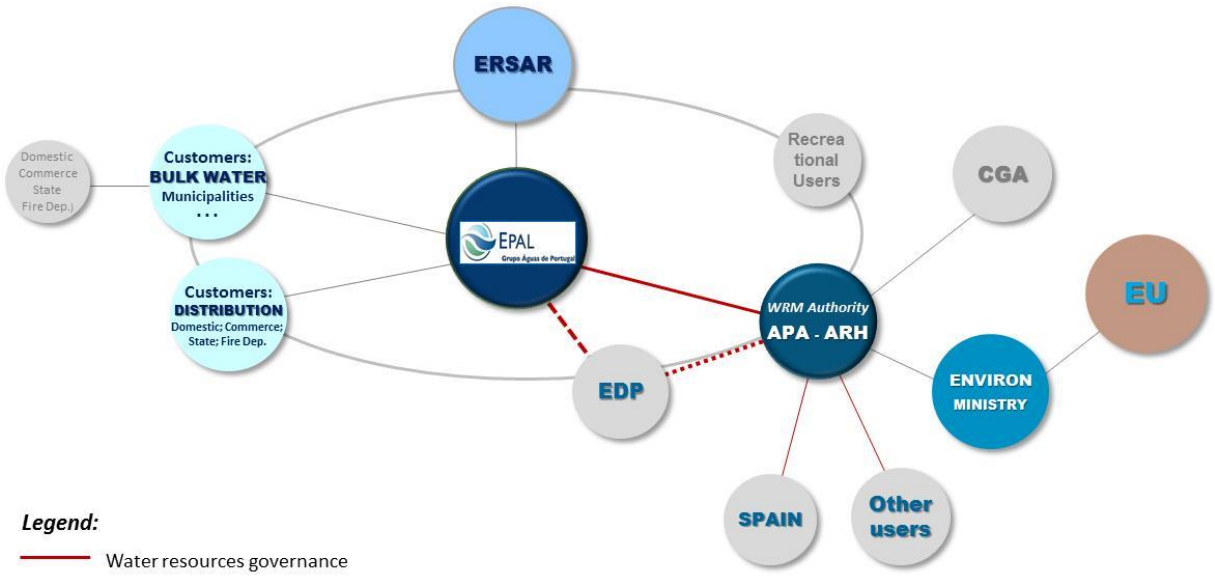
The stakeholders include: regulators; local government authorities (e.g. municipalities); regional water boards; authorities for basin management; environment authorities; other water users (e.g. recreational uses, agricultural uses, industrial uses); non-governmental organizations (e.g. associations of domestic consumers, associations representing the general public).

The most relevant stakeholders are the following (Figure 6.7):

- **Customers**:
  - 17 Municipal customers: Alcanena, Amadora, Batalha, Cartaxo, Cascais, Constância, Leiria, Loures, Mafra, Odivelas, Oeiras, Ourém, Porto de Mós, Santarém, Sintra, Tomar, Vila Franca de Xira;
  - 2 Multi-municipal customers: Águas do Oeste and Águas do Centro (merged with Águas do Ribatejo), supplying 14 and 3 municipalities, respectively;
  - Direct customers in and outside Lisbon with the following number of customers in 2013: 298,992 domestic, 41,318 industry and trade, 4 269 State, Lisbon City Council and Embassies, 2652 Private institutions under public law and 2 Military facilities;
- **ERSAR** - Regulatory Authority on Water and Waste Services. The regulation of Water Quality is the responsibility of ERSAR, which is the competent authority for the quality of water for human consumption;
- **APA/ARH Tejo** - Portuguese Environment Agency (APA) and the River Basin District Administration of Lisbon and Tagus valley. EPAL, being an entity that

uses water resources, is also subject to the Portuguese Environment Agency (APA). Among others, APA has the role of National Authority for Water and, within this scope, it is responsible for issuing licenses for the use of water resources and supervising their application, enforcing the economic and financial regime for water resources and managing drought and flood situations, coordinating the adoption of exceptional measures in drought or flood situations and addressing disputes with users related to obligations and priorities resulting from the Water Law and complementary regulation. APA also coordinates with the Ministry of Environment to negotiate discharges with Spain;

- **EDP** - Electricity of Portugal. Electricity producer, shares the Castelo do Bode reservoir management together with EPAL;
- Representatives of **recreational uses** of Castelo do Bode reservoir.



APA	Portuguese Environment Agency (National Water Authority)
ARH	River Basin District Administration or Hydrographic Region Administration
CGA	Reservoirs Management Commission
EDP	Electricity of Portugal
EPAL	Public Water Supply Company to Lisbon and all the right margin of lower Tagus river
ERSAR	Regulatory Authority on Water and Waste Services
EU	European Union

Figure 6.7: Key stakeholders for the Tagus public water supply RMP

6.2.1.4. Risk Objectives, scope and criteria to evaluate the risk

Assure efficient production of drinking water, is the objective of the full risk management process that will be performed within the BINGO project by **EPAL, the risk owner.** The objectives of EPAL for the Risk Management Process are directly related with their responsibilities and mission: Assure efficient production of drinking water. The main RMP objective of EPAL is the management and exploitation abstraction and transport infrastructures during extreme weather conditions, assuring at the same time profitability of the shareholder and the good image acquired since long ago.

The specific objectives identified by EPAL are the following:

- To supply water with adequate quality, i.e., that it will not harm customers' health. Failing to meet this objective will mainly affect the customers.
- To supply water in adequate quantity, i.e., meeting every customer's needs (regardless of the reliability of supply or the water quality). Failing to meet this objective will mainly affect the customers.
- To supply water with adequate reliability, i.e., ensuring the continuity of the supply (regardless of the water quality or quantity). Failing to meet this objective will mainly affect the customers.
- To guarantee the economic and financial sustainability of the business, in the long term. Failing to meet this objective will mainly affect the shareholder.
- *To guarantee adequate levels of business profitability, each year*. Failing to meet this objective will mainly affect the customers and the shareholder.
- To ensure the trust from the customers as well as the reputation among other national or international water utilities.

The objectives, scopes and specific objectives formulated for the risk management process are summarized in Table 6.2, as well as the factors to have into consideration as the basis of the criteria to evaluate the risk.

The main risks in what concerns quantity are: drought, competition for water uses, with agriculture where abstraction sources do exist, hydropower generation in Castelo do Bode; other dams in Spain, water losses increase, consumption increase. The main risks in what concerns quality are: drought, diffuse pollution, point source pollution, forest fires, failure in suppliers, vandalism. The main risks in what concerns the financial strategic objectives are for example increase of energy costs, limitation on setting tariffs, reduce consumption, inadequate maintenance, assets ageing.

Table 6.2: Tagus RS – Objectives and scopes of the risk assessment processes of EPAL (PWS)

RISK OWNER	OBJECTIVES	SCOPES	SPECIFIC OBJECTIVES	RISK CRITERIA FUNCTION OF:
EPAL	**Assure efficient production of drinking water** in climate change scenarios	**Continuity of water production** (related to water intakes). (Fulfil needs and expectations of customers)	To supply water with adequate quality (i.e., that it will not harm customers' health)	Daily Average Flow % (Volume supplied)/ (Volume requested) Duration (month)
			To supply water in adequate quantity (i.e., meeting every customer's needs	Daily average flow: % (Volume supplied)/ (Volume requested) Duration (month)
			To supply water with adequate reliability (i.e., ensuring the continuity of the supply).	Number of clients affected by the lack of water supply, and/or Duration of the service failure
		Profitability: Ensure adequate profitability	To achieve the economic and financial strategic objectives	Loss of profits due to Opex increase
		Image	To ensure the trust from the customers as well as the reputation among other national or international water utilities	Nº, type and subject of Negative news in the media per year

6.2.2 Establishing the external context

The Water supply and sanitation sectors in Portugal have seen important advances in access to services, technologies used and service quality over the past decades (1980s–1990s), partially achieved thanks to important funds from the European Union. Besides EPAL–before the 1990s water supply in Portugal was totally assured by municipalities' services, with a low coverage of the population served by drinking water and very low sanitation coverage, mainly out of the principal urban centres. During the 1990s Portugal has put in place a modern institutional framework for the water supply sector, which included the founding of:

- Águas de Portugal (AdP), in 1993, integrated into the Portuguese State Investment and Holdings vehicle (IPE), with an attributed responsibility for the development of Multi-municipal Water Supply and Wastewater Sanitation Systems. EPAL company was, since then, 100% owned by AdP;
- the first concessionary companies, in 1995, running water supply multi-municipal systems: Cávado, Douro e Paiva, Barlavento Algarvio and Sotavento Algarvio;
- a national regulatory agency, in 1997, which is now called the Water and Waste Services Regulation Authority - Entidade Reguladora dos Serviços de Águas e Resíduos (ERSAR); it is in charge of water supply, wastewater and solid waste management and its attributions include the economic regulation of service providers, as well as the regulation of their service quality, including water quality.

Within the past decades, substantial progress in the physical access to WS services (> 95%) did occur in Portugal. The provision of water and sanitation services is nowadays a shared responsibility between the 308 municipalities and the national, public holding AdP company and its subsidiaries, along with several private companies operating in the water supply market. About 73% of the population in 243 municipalities receives water directly from municipalities (3.5 million people) or single-municipality companies established under public law (2.5 million people). 27% of the population receives water directly from private companies, including 1.7 million from multi-municipal companies majority-owned by AdP and 0.9 million from other municipal companies established under private law.

Many municipalities do not control their sources of bulk water supply. Companies established under private law, in particular multi-municipal companies co-owned by AdP, thus sell water to municipalities, providing water indirectly in bulk to 53% of the

population. In addition, as mentioned above, private companies provide water directly to 27% of the population. Thus, a total of about 80% of the population receives water directly or indirectly from multi-municipal companies. Independently of whether utilities are public or private, all infrastructures are publicly owned. There is only limited private sector participation in the provision of water and sanitation services. Storm water drainage is directly provided by the municipalities.

Water supply and distribution in Lisbon is, since 1868 year, assured by EPAL, Empresa Portuguesa das Águas Livres, which was, until 1975, a private owned company named CAL – Companhia das Águas de Lisboa. The company is nowadays responsible for the delivery of water to households in the capital (Lisbon), where it has around 350,000 clients. In terms of its bulk operations, EPAL supplies water to 35 municipalities on the north bank of the river Tagus and, since 2015, it was delegated management responsibility for the multi-municipal water supply and sanitation systems of Lisbon and the Tagus Valley, which integrates 86 municipalities. In total, EPAL is now responsible to manage the water supply to a population of around 3.8 million inhabitants in a territorial area making up 33% of mainland Portugal.

The external context that affects the water sector and the EPAL strategic objectives, having a strong impact on the economic and financial profitability and sustainability of this PWS company, is summarized through PESTLE analysis in Table 6.3.

6.2.3 Establishing the internal context

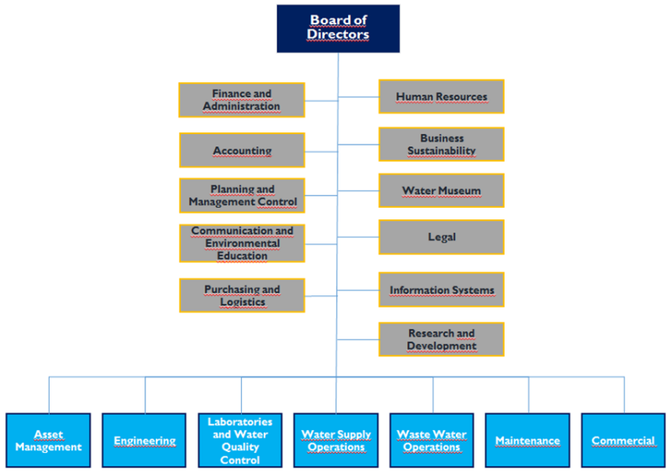
The risk owner is EPAL - Empresa Portuguesa das Águas Livres, S.A., the water company serving Lisbon and surrounding municipalities. Table 6.4 summarizes the internal context of EPAL Company.

Table 6.3: Tagus RS - External context for the RMP of EPAL (PWS)

PESTLE dimension	RS KEY ISSUES	LIST
POLITICAL	Organisational changes	**International context:** In 2000, through the Millenium Development Goals (MDGs), the international community committed to halving the proportion of people without access to clean water and basic sanitation by 2015. In 2010, the United Nations has declared the access to supply and sanitation services as "human right, having the Member States an obligation to promote all necessary measures. Portugal, namely through European programs, has put an immense investment since 1990 years and is on track to meet the water MDG, in what concerns water supply and sanitation. **Nacional Context:** In 2000, the Portuguese government published the first Strategic Plan for the Supply of Water and Wastewater Sanitation - Plano Estratégico de Abastecimento de Água e de Saneamento de Águas Residuais (PEAASAR) 2000-2006; promoting the modernization of the sector and the consolidation of service provision; the objectives for Portugal were to achieve over the period 2000-2006, a 95% coverage of the population served by drinking water; investments were focused in infra-structures for water abstraction, treatment and transport. In 2005, the Water Law was published and transposing into the national juridical framework the EU Water Framework Directive. In 2007, a new Strategic Plan for Water Supply and Wastewater Sanitation was also published for the 2007-2013 (PENSAAR 2007-2013); within this strategy investment continue to be focused in water infra-structuration. The AdP Group was reorganised within the scope of focusing more closely on the Multi-Municipal Water and Wastewater Systems and in 2009, it established a new model for the integrated management of the urban water cycle based upon the signing of partnership contracts between the state and municipalities with the first partnerships established in the regions of Aveiro and Alentejo, with their operation and management attributed to the Águas de Portugal group. In 2012, the process of reorganising the water sector was launched within the objectives of ensuring the continuity, universality, quality and sustainability in the provision of essential public services. Some restructuring guidelines, issued by the Governmental Programme, to restructure the Water and Waste Sector, strongly affected EPAL policy and strategy: • Reorganising the water supply and waste water sanitation sector, prioritising its economic and financial sustainability; • Proceeding with the calculation and solving of the tariff deficit, reviewing the tariff system, showing greater openness to the participation of private entities in the operation and management of the different systems, • promoting efficiency, vertical integration and aggregation of demanding systems, proper maintenance of old networks and equipment and avoiding the building of unnecessary capacity. In Portugal, the goal of restructuring of sector has materialised in several legal documents and legislative initiatives: Law no. 35/2013 of 11 June, introduced amendments to Law no. 88-A/97 of 25 July, called the Sector Delimitation Law, in order to allow sub-concession to private entities, with the grantor's authorisation, of concessions associated with the abstraction, treatment and distribution of water for public consumption, and the collection, treatment and disposal of urban waste water. Projects for the aggregation of several existing multi-municipal systems and their respective management entities, following the publication of Decree-Law no. 92/2013 of 11 July, the scope of which already includes the creation of three new multi-municipal systems through the aggregation of existing ones; Creation of a new public partnership and further negotiations for the conclusion of public partnerships with municipalities that are integrated within the scope of multi-municipal systems, by delegating the operation and management of municipal systems aggregated through public partnerships to companies that will manage the concessions of multi-municipal systems, thus "integrating" the service into a single managing entity. In 2014, a new strategic plan for restructuring the water sector for the period through to 2020 was launched (PENSAAR 2020). Main conclusions are: i) substantial progress in the physical access to WS services (> 95%) did occur in Portugal with the past decades but need to invest in WW infrastructure by specific objectives, e.g. improvement of the quality of the water bodies, legal compliance; ii) good drinking water quality, but other parameters concerning the quality of the service to the users need improvement. Need to invest in the efficiency of systems and its management, optimisation of assets and iii) Problems of economic and financial sustainability. The cost recovery in parallel with the minimisation of the costs is necessary to ensure its sustainability as well as the social one. A new financial support program (POSEUR) was defined and, in contrast with previous funding mechanisms, where investment were focused in water infra-structuration, investments are focused on the operation and maintenance of existing infrastructure to achieve sustainable service delivery; this program, also envisages strengthening of the economic regulation, with new statutes for ERSAR and the detailed invoice law coupled with the overall reorganisation of the AdP Group.
ECONOMIC.	Economic development/state of the economy	The size and future development of Portugal's economic output, expressed in terms of real GDP, average annual growth, and origin (expenditure approach). Portugal faced recently a recession, with intervention from the IMF.
	Funding mechanism	POSEUR (2014-2020), the new financial support program of PENSAAR 2020; the strategy for funding is less centred in new infrastructure to increase the population served and focuses more on the management of the sector assets, its operation and the quality of the services provided with an overall sustainability; However, EPAL is not covered by it, given its solid financial situation.
	Energy prices	The cost of energy in all forms (gas, electricity, etc.) used in sourcing, treating and providing water resources, has been increasing.

	Water prices	In Portugal, there are rules which regulate the water market. The most sector policies Economic Regulations are as follows: the pricing system applicable to the selling of water by EPAL, are established through an Agreement between the Directorate-General of Economic Activities and EPAL, which is subject to the joint ratification of the Ministries of the Environment, of Territorial Planning and Energy, and of Economy. The Agreement complies with the price-setting system established by Decree-Law no. 230/91 of 21 June and with the consumer qualification established by Ordinance no. 6-A/92. EPAL's tariff proposals are based on the pricing policy principles applicable to public water supply services, framed within the Water Law, in which water is considered to be a scarce economic resource, essential to life and to economic activities; therefore, we must assign it its fair value, and its price must reflect the real cost of the supply, environmental costs and scarcity. The underlying goals to the setting of tariffs are enshrined in the Water Law, in its article 82(1) and in Decree-Law no. 230/91 of 21 June, which establishes, in article 10, that the calculation of the tariff must generate revenues that allow for: i) an appropriate return on invested capitals; ii) appropriate self-financing levels; iii) the coverage of operating costs.
SOCIAL	Population size/demographics	Demographics in the supply region of the company have been stable in the last surveys and substantial changes in population are not expected to occur, for the next years.
	Consumption patterns and environmental behaviour	The water consumption has had a significant reduction in the past ten years, due to changes in personal behaviours.
TECHNOLOG.	Infrastructure development	The company has been putting in place a developed asset management approach, and practices, in planning new infrastructures and dealing with the issue of asset ageing. Risk management tools are currently used on prioritizing investment needs.
	Technology development and recent opportunities	The water losses reduction has been a driver to develop "in-house" technological solutions, which simultaneously arose has a new business opportunity, selling services to other water companies with similar challenges. Water loss reduction and efficiency measures have contributed to an expressive reduction in energy consumption, although not fully reflected in cost decrease, as energy costs increased significantly in Portugal, for the past recent years.
LEGAL	Regulation and legislation (EU and national)	In Portugal, the Ministry of Environment and Regional Development is in charge of sector policies. As in many other countries, water and sanitation is not a political priority. Political actions at the local level are often oriented at the short-term, following electoral cycles, with limited long-term planning. Nevertheless, there has been remarkable stability of the national policy framework independent of electoral cycles. In what concerns, EPAL the most important regulations are described as follows. Regulation of the Service Quality The Regulation of the Service Quality is ensured by the Water and Waste Services Regulation Authority - ERSAR [Entidade Reguladora dos Serviços de Águas e Resíduos], which also covers its monitoring and assessment using a series of indicators, benchmarking the different management entities in the water and waste sectors and publishing the results in its yearly report on the sector Water Quality Regulation The Decree-Law n.º 306/2007 transposes for the national law the Directive n.º 98/83/CE, related with the drinking water quality. The regulation of Water Quality is also the responsibility of ERSAR, which is the competent authority for the quality of water for human consumption. As of 2008, Decree-Law no. 306/2007 of 27 August is the legal provision that regulates the quality of water for human consumption, defining the sampling and analysis frequency to be performed at delivery points to management entities, at direct customers supplied through the transportation network and on the taps of consumers in the city of Lisbon. It also establishes the quality standards for each parameter whose control is mandatory. Environmental Regulation The Decree-Law n.º 236/98, transposes for the national law the Directive n.º2008/105/CE, related with the water resources. The entities that manage water services are also subject to the Portuguese Environment Agency (APA), the environmental regulator, also with the responsibility of water resources management; APA, follows the former Water Institute INAG, created in 1993 under the Ministry of Environment and Regional Development and operates, among others, on the basis of the 2005 Water Law, which transposes the EU water framework directive into national law.
ENVIRONM.	Water quality	Alterations in water composition and sediment associated with pollutant load, are not being reported.
	Water availability	Average water flow available in catchments has not been an issue, so far, for the WPS.
	Climate Change	Currently, changes in precipitation, temperature and extreme events' patterns did not cause problems in the water supply region.
	Land use change	Intensive agriculture in the Lezíria region may cause further pollution problems in Tagus river and aquifers, as intensive forestation (eucalyptus) in the Castelo do Bode reservoir margins may cause major quality problems due to forest fires and, in the long term, soil erosion.

Table 6.4: Tagus RS - Internal context for the RMP of EPAL (PWS)

i. Governance
EPAL's governance is assured by the following management bodies (figure 8): (i) general council, whose only member is the holding company Águas de Portugal, that has the roles of evaluating and voting on the reports and the annual accounts, electing the members of the management bodies, deliberating on the statutes and capital increases, authorizing the acquisition and alienation of capital as well as the realization of investments worth more than 20% of the share capital; (ii) board of directors, composed of five members who are elected by the general council and are appointed for a three-year period, that may be renewed; (iii) supervision authority, which supervises the company and legally certifies the accounts; (iv) remuneration committee, which establishes the remuneration of the members of the management bodies; and (v) advisory council for the sustainable development, which sets out recommendations regarding the environmental sustainability of the company's activities. Figure 6.8 presents the organizational structure of EPAL.    **Figure 6.8: Organizational structure of EPAL**
ii. Goals and Objectives
1 - Fulfil needs and expectations of customers: 1a - To supply water with adequate quality, i.e., that it will not harm customers' health. 1b - To supply water in adequate quantity, i.e., meeting every customer's needs (regardless of the reliability of supply or the water quality). 1c - To supply water with adequate reliability, i.e., ensuring the continuity of the supply (regardless of the water quality or quantity). 2 - Fulfilment of sustainability of the business shareholder in long term 2a - To achieve the economic and financial strategic objectives 2b - To ensure the trust from the customers as well as the reputation among other national or international water utilities
iii. Strategies
Strategies that are successful: 1 – A leakage reduction policy that includes an extensive monitoring program to optimize the water network efficiency. As a result, the company has reduced water loss levels in the Distribution Network; 2 – Still, in the field of water efficiency and demand management, the company has developed campaigns promoting the correct and responsible use of water; also created and made available

apps and tools for consumers' self-control to increase household water efficiency (ex: waterbeep);

3 – The Water Quality Control Plan (WQCP) is established annually and takes into account compliance with the legislation, the protection of consumer health and the security level of the service provided, allowing the identification of abnormal situations in a timely manner and implementing preventive and remedial measures. The Water Quality Monitoring Directorate is the organ of EPAL that has the responsibility to carry out the design, implementation and management of the WQCP. It integrates: i) the water quality control in the sources: realization and analysis of water samples on the various EPAL sources, to assess the evolution of the quality of the raw water and trace any anomalous results; ii) the treatment process control at Asseiceira and Vale da Pedra WTP and in the Alenquer underground water abstractions iii) the tap water quality control in Lisbon, in the water supplied to multi-municipalities and municipalities water agencies and to direct clients through the adduction/transport systems (in mixing points of water from different sources occurs and in characteristics points of water deliverability in the transport system) – 58 sampling points

4 - EPAL has an Emergency General Plan that shows, in simplified form, the organization, management and response setting to emergencies that may affect the operation of the Water Supply System for Human Consumption.

5 – EPAL promoted the development of competences on Strategic Risk Management, namely Climate Change related strategic risks, and also the study of current and future Systems' vulnerabilities.

6 - This knowledge has made it possible for the company to establish a set of critical climate changes indicators and to monitor them periodically on a perspective of risk management.

7 - Inspection of water supply infrastructures System - consisting in the systematic assessment of the physical condition of EPAL operating assets. This system is based on a maximum frequency of inspection of each active within a maximum period of 5 years to support decisions on priority investments to be carried out, within the framework of the Multi-annual Investment Plan EPAL, and to recommend necessary maintenance actions to ensure a good conservation status of operational infrastructures.

8 - Demarcation of protective perimeters of EPAL groundwater catchments, technically designed and established by law, conditioning activities in the wells' surroundings.

9 - EPAL invests in innovation and development, seeking to foster corporate innovation, rewarding the in-house development of projects that contribute to the efficiency and efficacy of the company's processes and operations.

Strategies that are not (so) successful:

Strategies consisting on "hard" adaptation measures representing huge investments with little adherence to current situation and to prevent future vulnerabilities with little likelihood to arise (ex: desalination plants). None of this strategies have been implemented by the company.

Strategies that are planned for the future:

i) Increase in quality of service to the client**:**

- deactivate some of the underground water intake points;
- refurbishment of the treatment processes at Vale da Pedra WTP (currently ongoing)
- Promote formal cooperation agreements in the joint management of resources and infrastructures (ex: EDP)
- Increase of interconnections and, thus, redundancy between subsystems in EPAL network

ii) Water use efficiency:

- EPAL has led innovation by presenting pioneering solutions, among which is the WONE® system for increase in efficiency and controlling losses in the network. This system's excellence has been recognized at national and international level, with the awards of the Green Project Awards, a Gold Tube at ENEG, and the WEX Global – "Water and Energy Exchange".
- Continuous rehabilitation of pipelines in the transport system
- Remote surveillance, information and communication technologies
-

iv. Resources
STAFF: EPAL had, in 2014, a total number of 675 workers.
INFRASTRUCTURES: • Castelo do Bode reservoir: Dam high: 115 m; Reservoir net storage capacity: 902,5 x 106 m^3; Daily production capacity: 625,000 m^3; Installed generation capacity: 159 MW • Valada water intake: Daily abstraction capacity: 240,000 m^3 • Asseiceira WTP: Treatment capacity: 625,000 m3/day; General scheme: mineralization coagulation/flocculation, flotation, filtration and final disinfection (chlorine) • Vale da Pedra WTP: Treatment capacity: 220,000 m^3/day; General scheme: pre-oxidation with ozone (after WTP refurbishment conclusion), conditioning of PH, coagulation/flocculation, decantation, filtration (one depth sand thickness), PH correction of the treated water and final disinfection • 18 undergroung collection points; Treatment capacity: 225,000 m^3/day
EQUIPMENT: • 710 km of trunk mains • 31 pumping stations • 28 water tanks • 19 chlorination posts
INFORMATION SOURCES relative to: • Asset Management, including registration and Geographic Information System relative to the whole system and assets performance and condition assessments • Daily volumes of water abstracted, produced and supplied to all kinds of clients • Volumes of water losses • Financial and accounting processes • Clients, water metering and invoicing • Annual volumes of water required • Water storage • Volumes of energy used in abstraction, treatment and pumping operations • Volumes of chemicals used in water treatment
TECHNOLOGY: Very good: The operation of EPAL PWS is managed through a SCADA system (remote system), that is highly automated and centralises operation and control in real time of more than 170 facilities ranging from pumping stations to treatment stations, from reservoirs to valves; EPAL holds a Central Laboratory that has been accredited in accordance with standard NP EN ISO/IEC 17025, with Certificate No. L0242 since 1999, for 171 parameters/species, including the collection of samples. Another facility, the Vale da Pedra Laboratory, was accredited in 2008 in accordance with standard NP EN ISO/IEC 17025, with the support of incentives granted under the PRIME programme. It holds Certificate No. L0242 for 19 parameters. The Water Meter Laboratory was accredited on 07 July 1994 by the IPQ (Portuguese Quality Institute), in accordance with standard NP EN ISO 45001, to carry out tests on the water meters. It is currently accredited by IPAC, in accordance with standard NP EN ISO/IEC 17025, as a Calibration Laboratory and Test Laboratory for mechanical and non-mechanical clean cold-water meters. Needing improvement: • Possible need for installation of online analysers for early warning detection of water contamination upstream surface catchments; • Refurbishment of Vale da Pedra WTP to cope with possible worsening of water quality in Tagus – in progress; • Cooperation agreements with licensor and inspection entity for sharing knowledge and information on the risks of pollution upstream catchments.
FINANCING SOURCES: • Sales of water (EPAL is a profitable company; in 2015 - 47M€) • Revenues from services to clients

v. Internal culture

The Principles of action of EPAL, SA, in pursuit of its mission must take into account:

- Respect and protection of human rights;
- Respect for workers' rights;
- Respect for gender equality;
- Fight against corruption;
- Eradication of all forms of exploitation;
- Eradication of all discriminatory practices;
- Responsibility in defending and protecting the environment.

EPAL undertakes to abide by 9 Principles, which make its Policy for the Integrated Corporate Responsibility System (SIRE); such Principles were approved by the Board of Directors Meeting in June 2012. Three relevant environmental sustainable development principles (among a total of five) taken by EPAL are the following:

- Eco-efficiency and Environmental Protection: To promote the protection, conservation and efficient use of water in its catchment area of intervention, in all the water life cycle stages, from the production of water to its use and discharge by customers.
- People Protection and Development: To promote the integrity, trust and transparency in its way of engaging with internal stakeholders (employees, suppliers and service providers) and external stakeholders (customers, government bodies, society), promoting a safe and healthy work environment through the development of skills, jobs and equal opportunities.
- Society's engagement in Sustainable Water Management: To take on an active and visible role in the society in which it is integrated, fostering and promoting rational management water policies with stakeholders and, insofar as possible, with the international community.

EPAL is certified in Environmental Management by:

- 2002 | Management System certified by APCER – NP EN ISO 14001:1999
- 2005 | Transition to NP EN ISO 14001:2004

EPAL is certified in Quality Management by:

- 2003 | Management System certified by APCER – NP EN ISO 9001:2000 – Retail Clients
- 2010 | Transition to NP EN ISO 9001:2008 – Retail Clients
- 2011 | ISO 9001:2008 extended to the remaining Clients Area, Commercial Management Process and Assets Inspections
- 2012 | ISO 9001:2008 extended to the whole Company

EPAL is also certified in Occupational Health and Safety by

- 2014 | OSHAS 18001:2007

The supply of water for human consumption, including its collection, treatment, storage, transport, distribution, supply and related activities developed in EPAL's catchment area is also certified under certificate number 2002/AMB.76

6.3. Agriculture

6.3.1 Risk approach within BINGO

6.3.1.1. Adaptation objectives within BINGO

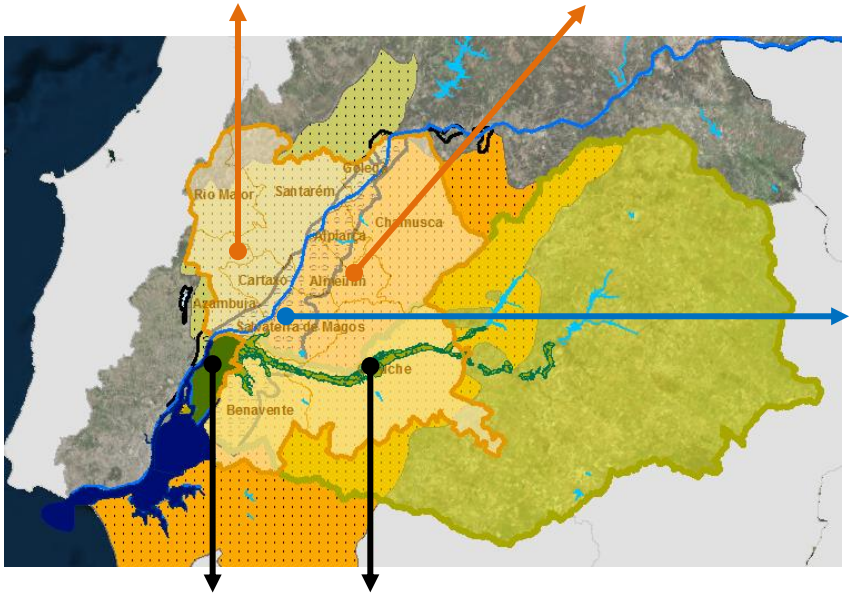
The agriculture sector in BINGO is mostly focused on two different cases of public irrigation perimeters (PIP), the **Sorraia Valley** and of **Lezíria Grande de Vila Franca de Xira –** LGVFX (hereinafter called "Lezíria Grande"), the former disposes of private storage capacity through damming, and the later totally depended till very recently of the Tagus river flow and quality (Figure 6.9). A public irrigation perimeter means that the irrigation infrastructures (storage, transport and primary distribution) were built or funded by the Portuguese Government, but farming lands and agriculture practices are private.

The Lezíria Grande (LGVFX) is an area prone to estuarine inundations due to its low topography, being totally surrounded by protection dykes.

The main objectives in BINGO are to strengthen the economic agriculture sector by developing strategies for climate change adaptation in the lower Tagus under low precipitation (droughts) and to identify the risk associated with inundation due to spring tides combined with storms surges and sea level rise scenarios.

For the Sorraia PIP case a full risk assessment will be performed in BINGO WP4 and risk treatment will be developed in WP5, both at research site level as at governance level. The LGVFX will be subject of a risk assessment process but no site risk treatment will be developed in WP5. Nevertheless, governance issues will be addressed.

How water resources governance as well as agriculture governance can be improved to facilitate sectoral adaptation is a key issue to be addressed. The farmers **of Lezíria do Vale do Tejo – LVT**, the remaining important agricultural area of the lower Tagus (MD and ME in Figure 6.9), do not benefit from public irrigation infrastructures, dealing with a distinct reality. Rain-fed agriculture and intensive irrigated farming, with private irrigation systems, are the common practices in the region. Water resources governance related risks concerning those farmers will be identified (risk identification), in order to contribute to a comprehensive governance improvement approach of the Tagus research site, to be developed in WP5.



MD - Lezíria do Vale do Tejo (right margin)
Private irrigation: mainly using groundwater but also superficial sources

ME - Lezíria do Vale do Tejo (left margin)
Private irrigation: mainly using groundwater but also superficial sources

Valas do Tejo:
Superficial sources

Lezíria Grande VFX
Public Irrigation Perimeter
Superficial sources

Sorraia Valey:
Public Irrigation Perimeter
Superficial sources

Figure 6.9: Most representative types of irrigation in the Tagus RS

6.3.1.2. Characterization of the research site from the risk assessment point of view

a) Sorraia Valley Public Irrigation Perimeter (PIP)

The Sorraia Valley PIP, located along a short strip of land along the Sorraia river (Figure 6.10), benefits a total area of 16.365 ha. Its influence area covers six municipalities of 3 districts: Portalegre – Ponte de Sôr and Avis; Évora – Mora and Santarém – Coruche, Salvaterra de Magos and Benavente.

The main cultures are: maize, rice and tomato. Tomato canning processing is quite relevant in the region. Portugal is placed among the 10 major world processed tomato exporters (varying between 5th and 8th position). Droughts affecting tomato production affect a whole chain of post-production with national economic impact.

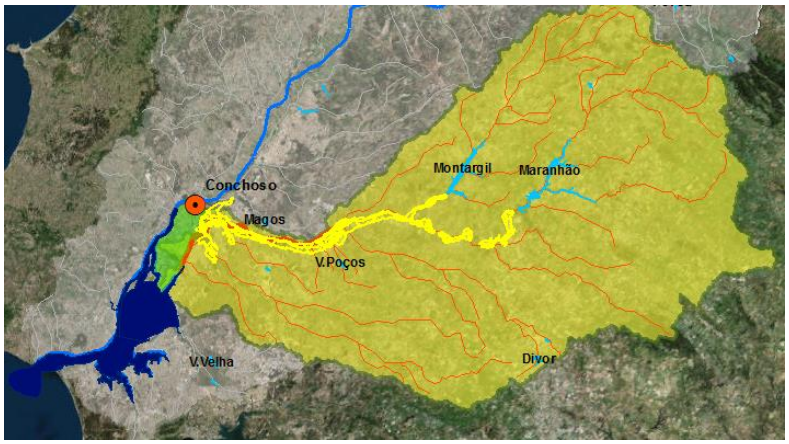


Figure 6.10: Agricultural areas in Tagus research site: Irrigation public perimeters of Sorraia Valley (in yellow) and of Lezíria Grande (in green).

The type of agriculture practised in the region is quite developed and efficient, either from the water use point of view (state of the art irrigation techniques) as from the use of good farming practices (rational fertilizers and pesticides application).

The main feature of the Sorraia Valley PIP is its storage capacity, able to endure at least one year of drought. 3 dams and 2 weirs provide enough storage for agricultural campaigns and allow for electric production that is sold to the public electric network. As already mentioned, farmers are associated in an agriculture association: the Associação de Regantes e Beneficiários do Vale do Sorraia (ARBVS) to manage and exploit the irrigations infrastructures, either storage (Figure 6.11) as transport and primary distribution (Figure 6.12).

Figure 6.11: Sorraia valley PIP: water storage (3 dams and 2 weirs)

Figure 6.12: Sorraia valley PIP. Water distribution (channels and floodgates)

In average years, the water allocation is processed peacefully. In short duration droughts, an apportionment strategy is peacefully put in place.

Farmers and the ARBVS worry about future longer duration droughts under climate change conditions and the economic and social impacts that may occur.

b) Lezíria Grande de Vila Franca de Xira Public Irrigation Perimeter

The Lezíria Grande PIP covers an area of 13420 ha and is located in the Metropolitan Area of Lisbon, about 25 km upstream of Lisbon, in the municipalities of Vila Franca de Xira and Azambuja (Figure 6.13). The Irrigators Association of LGVFX (ABLGVFX - Associação de Beneficiários da Lezíria Grande de Vila Franca de Xira) is responsible for the management of this PIP. The Lezíria Grande is located in the transition between the Tagus estuary and the Tagus and Sorraia rivers. This area is characterized by low elevation terrains (the elevation varies from 1 to 2 meters above mean sea level), with alluvial soils mainly of fluvial and local origins, and is surrounded by protective dykes. The Lezíria Grande is extensively used for agriculture and its southern area is also part of the Tagus Estuary Natural Reserve (see Deliverable 3.1 for further details).

Figure 6.13: General map of the Lezíria Grande de Vila Franca de Xira PIP. Main drainage channel (blue line) and gates for water intake and drainage – "Portas de Água" (yellow circles). Background image from ESRI basemap. Adapted from ARHT (2009).

The main crops in this area are rice (4082.4 ha), tomato (2923.2 ha) and corn (1019.4 ha), which represented about 91% of the cultivated area in 2015. Over the past 20 years, both rice and tomato crops have increased significantly in the region. Rice has been preferably cultivated in the southern area of the Lezíria Grande due to its higher tolerance to salty water. The annual investment in crops is about 60 million Euro. During the irrigation period (Spring-Summer), the agricultural activities in this area involve about 6000 direct jobs and some additional indirect jobs to the companies providing services and equipment to the sector (https://www.publico.pt/local-porto/jornal/fecho-do-rio-sorraia-salva-culturas-da-leziria-grande-de-vila-franca-36092, accessed on February 12, 2016).

Several water intakes are located in the Tagus, Risco and Sorraia rivers that supply the freshwater for irrigation in the Lezíria Grande, namely: Conchoso in the Tagus river; Barrão, Arcaus and Marqueira in the Risco river; and Condessa and Corte Nova in the Sorraia river (Figure 6.13). The main water supply to the Lezíria Grande is done through the Conchoso water intake, which has design flows of 35.7 m^3/s (first phase) and 54.5 m^3/s (second phase). Presently, the water intake from these rivers is mostly done by gravity, but a pumping system was recently installed at Conchoso. Since the Conchoso water intake is located close to the limit of the salinity propagation in the Tagus estuary, the water abstraction can be limited by the tidal phase and the river flow. Moreover, during very dry periods, the salinity at this water intake can reach concentrations that are inadequate for the crops. During these periods the water abstration is done, exceptionally, through the Risco and Sorraia water intakes. Generally, the irrigation period goes from April to October.

The whole Lezíria Grande is surrounded by a dyke that aims at protecting the farmlands from flooding. The total length of the dyke is 62 km, along the Tagus, Sorraia and Risco rivers. Topographic data of the dyke crest are available approximately between the Diogo and Condessa gates, in the Sorraia river, and Conchoso, in the Tagus river. In this 45.3 km long stretch, the crest height varies between 2.4 and 7.2 m above MSL, with an average of 4.2 m. The dykes are usually made of soils covered by vegetation, occasionally protected on their outer flanks by stones. In some areas, there are indications of internal erosions caused by water or by burrowing animals.

Floods

The flood occurrences that affect the Lezíria Grande have different origins: as a consequence of high water discharges in the Tagus and Sorraia rivers (riverine flood), mostly affecting the northern sector of the Lezíria; and/or due to estuarine high water

levels forced by tides and storm surges (estuarine flood) particularly affecting the southern area.

The most severe wind storm that occurred in the Iberian Peninsula in the 20th century hit the Portuguese coast on February 15th, 1941. The whole Tagus estuary was severely affected. Data included in a geodatabase of historical flood occurrences in the Tagus estuary (Rilo et al., 2015) shows that more than 20 persons were killed in the "mouchões" and a countless number of cattle was lost. According to Muir-Wood (2011), the houses in the town of Alhandra were flooded with more than 1 m of water, and 25 of its inhabitants drowned. Since this town is located on the margins of the Tagus estuary across from the Lezíria Grande, it is expected that the Lezíria Grande itself was flooded as well. Also, all the channels and dykes that existed in the Lezíria Grande were destroyed (Madaleno et al., 2006). A storm following a similar SW-NE path but clearly less intense, Xynthia, struck the Portuguese coast on February 27th 2010. Like in 1941, the storm coincided with spring tides, exacerbating its consequences. Again the data about this storm in Portugal are scarce. In the days preceding the storm landfall the river flows were high, and floods are reported in riverine towns, such as Santarém (http://otejo.com/2010/02/25/, accessed on February 5, 2016). In the Lezíria Grande, there is evidence of flooding during the 2010 February-March storms (Figure 6.14). During three consecutive days, witnesses report that the dykes were overtopped during the night and dawn.

Figure 6.14: Flooding during the 2010 February-March storms (source: ABLGVFX)

One of the riverine flood occurrences with the most relevant impacts in Lezíria Grande occurred in February 1979, during which the dyke suffered a rupture in both north and south sides. During flood occurrences in the Sorraia river, such as the one that

occurred in March 2013, the gate of Ponta da Erva is opened to avoid raising the water levels within the Lezíria Grande (Figure 6.15).

Figure 6.15: Fluvial flood from the Sorraia river: water levels at the weir of the Risco river and opening of the Ponta da Erva gate (March 27, 2013; April 1, 2013; source: ABLGVFX)

Droughts

Since the water intake for irrigation depends on the availability of freshwater water in the rivers surrounding the Lezíria Grande, droughts can have negative impacts in the agriculture in this area and, consequently, adverse effects on the local economy. Moreover, since the main water intake (Conchoso) is located close to the limit of salinity intrusion in the Tagus estuary and the water intake is limited by the tides, some of these impacts may be exacerbated. On average conditions, the saline tide reaches about 50 km upstream from the mouth, near Vila Franca de Xira. During droughts, saline water has been detected about 14 km further upstream, at the Conchoso water intake. During these periods, water scarcity usually starts in July, when all the investments in crops have already been made by the farmers. The maintenance of freshwater water availability in the Lezíria Grande is, thus, fundamental to guarantee the required water demands for the crops. Rice, in particular, requires 8000 m^3/ha more of water than the other irrigated crops.

The most recent droughts in Portugal, in 2005 and 2012, affected the agricultural activities in the Lezíria Grande. Emergency measures were undertaken to minimize the negative impacts of water scarcity and the loss of crops. Usually, the recommended threshold of salinity for irrigation water in the area is 0.8, with a maximum of 1, and the water demands in the summer (July and August) are of 1 m^3/s per 1000 ha. During July and August of both 2005 and 2012, salinity reached concentrations at the Conchoso water intake that were inadequate for irrigation. In 2012, in particular, water with salinity of about 1.1/1.2 was used for irrigation, which led to a decrease in the production. However, the adverse impacts of the 2005 drought were more severe for the farmers in the Lezíria Grande, since the drought itself was more severe and the ABLGVFX had fewer resources and was less prepared to deal with these events. In 2005, from mid-July onwards the water supply to the Lezíria Grande started to be made exclusively

from the Risco river water intake. However, in mid-August the salinity at the Risco river was of 1 (comparatively to typical values of 0.3) and a temporary weir was built in the Sorraia river to route the freshwater available in this river. Similar measures, although more timely, were undertaken in 2012, with an improvement of the water intake at the Risco River and the construction of the weir in the Sorraia River in July (Figure 6.16). To increase the resilience to droughts, the ABLGVFX recently made some improvements that included the installation of a pumping system at the Conchoso water intake, allowing the pumping of the water from the Tagus River during low-tide, and the construction of a removable weir at the Risco river.

Figure 6.16: Temporary weir in the Sorraia river during the 2012 drought (July 2012, source: ABLGVFX).

c) Lezíria do Vale do Tejo (LVT)

The Lezíria do Vale do Tejo (LVT), located north of the public irrigation perimeters (Figure 6.9), is also an important economic agricultural region, with expression at national level, situated in the downstream part of the Tagus River. Economic forestry, rain-fed agriculture and intensive irrigated agriculture are all significant in the Tagus basin. Within the LVT, irrigated agriculture is the most expressive (main cultures are rice, tomato and maize), followed by seasonal rain-fed cultures, usually typical of winter (vegetables and cereals), and often associated with forestry. Irrigation is practiced in the region at individual farmer level, with sources from both superficial and groundwater, or is practiced in a corporative way, through private irrigation infrastructures supplying a large number of farmers.

A particular case are the Valas do Tejo, an ancient irrigation system of channels (19th century), fed by gravity by the river Tagus, that beneficiate a very fertile agricultural area located in the vicinity of the river Tagus. Although having been built by the state more than one century ago, they are considered public irrigation infrastructures.

All these different realities are affected by extreme weather events, but to a varying extent. Being the Tagus river heavily modified, with the Tagus's flows directly related to reservoirs' discharges, water resources management practices in the basin affects directly water availability and quality for irrigation dependent from Tagus river.

6.3.1.3. Identification of risk owners and Key stakeholders

For each of the sites considered the **risk owners** are the following (Figure 6.9):

- *Sorraia Valley Public Irrigation Perimeter* (hereinafter called "Sorraia PIP") - ARBVS, the Irrigators Association of the Sorraia Valley (Associação de Regantes e Beneficiários do Vale do Sorraia), has the responsibilities of management, conservation and exploitation of the irrigation infrastructures of the Sorraia Valley PIP. **ARBVS acts as risk owner** of the risk management process being performed in BINGO;
- *Lezíria Grande PIP* - farmers are associated within the **ABLGVFX** - Associação de Beneficiários da Lezíria Grande de Vila Franca de Xira that **acts as the risk owner** of the risk assessment process being performed;
- *Lezíria do vale do Tejo* - Covering a large number of farmers, the risk owner will be referred as "**Farmers of LVT**" but in fact they will be represented by CIM LT – The Intermunicipal Community of Lezíria do Tejo, a BINGO partner, and by Farmers Associations in order to perform risk identification regarding water resources governance impact agriculture in the region.

The most relevant stakeholders are (Figure 6.17):

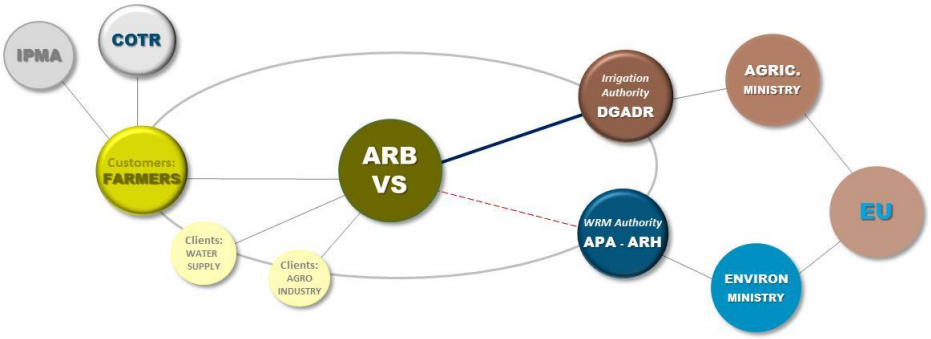
- The **European Union** sets environmental and agricultural policies that condition the external context. It is not really a stakeholder but condition the context:
  - Set Common Agriculture Policy (CAP);
  - Set financial framework programmes and objectives;
  - Set cross policies (agriculture & environment; energy, …);
- The **Ministry of Agriculture,** Forestry and Rural Development The agriculture Ministry (MAFDR), regulate and execute in Portugal:
  - The Rural Development Programme integrating CAP framework, objectives and financial programmes;
  - Direct payments to farmers (1st pillar CAP);
  - Cross policies (agriculture & environment; energy, …);
- **APA / ARH** (Portuguese Environment Agency (National Water Authority):
  - Enforces the economic and financial regime for water resources uses (under WFD);
  - Manages the basin water resources (quantity & quality) by:
    - Setting environmental objectives for the water bodies;
    - Issuing water abstractions licenses;

- Defining water protection measures in the River Basin District Management Plan;
- coordinating with the Ministry of Environment the negotiation of Tagus Spanish discharges to Portugal;

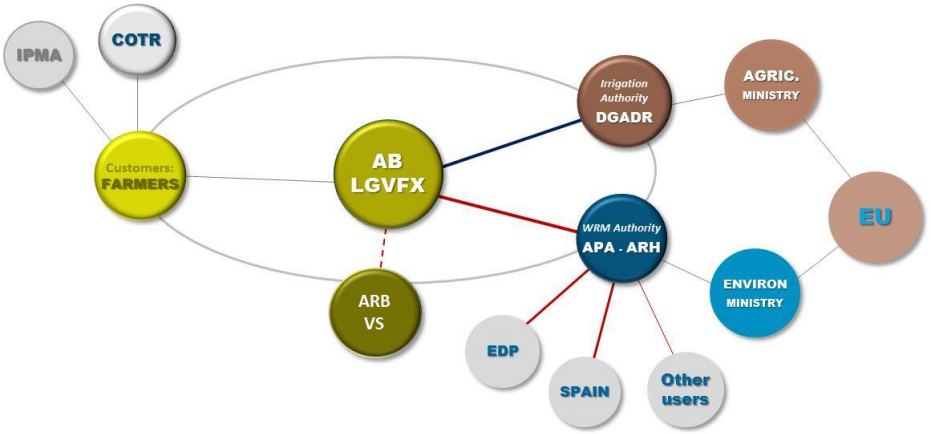
- Manages drought and flood situations, coordinating the adoption of exceptional measures with the Reservoirs Management Commission (CGA);

- **DGADR** (Directorate General for Agriculture and Rural Development):
  - represent Agriculture Ministry on agriculture water use issues;
  - assure management sustainability in public irrigation schemes (monitor and follow Irrigation Associations activity);
- **DRAP LVT** (Regional Directorate for Agriculture and Fishery of Lisbon and Tagus River Valley):
  - Supervises the private irrigation practices;
  - Publicize the code of good farming practice;
  - Establish reference irrigation water requirements;
  - Coordinate, monitor and follow the Nitrate Directive;
- **COTR** (Operative Centre and of Irrigation Technology):
  - Create technical capacity through:
    - The training of technicians;
    - The creation of support services to the irrigator farmer
    - Designers Certification;
    - Classification of irrigators (Class A or B);
  - Create installed operating capacity through:
    - Training of farmers;
    - Technical assistance;
  - Contribute to increase the capacity of research / experimentation / development by:
    - The involvement of the teaching activity / researcher / farmer;
    - Call attention to the need of opening calls of R&D projects with objectives oriented for solving concrete identified problems;
- **CIMLT** (Intermunicipal Community of Lezíria do Tejo) – represents the farmers and other water users of the lower Tagus;
- **EDP** (Electricity of Portugal) – important water resources user.

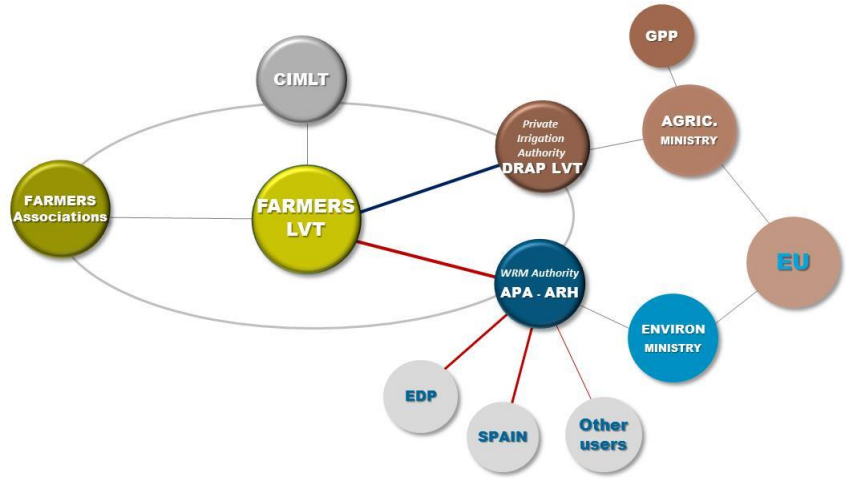
a)



b)



c)



Legend:

Water resources governance
Public irrigation infrastructures governance

ABLGVFX	Association of Beneficiaries of Lezíria Grande de Vila Franca de Xira
APA	Portuguese Environment Agency (National Water Authority)
ARBVS	Association of Irrigators and Beneficiaries of Sorraia Valley
ARH	River Basin District Administration or Hydrographic Region Administration
CIMLT	Intermunicipal Community of Lezíria do Tejo
COTR	Operative Centre and of Irrigation Technology
DGADR	Directorate General for Agriculture and Rural Development
DRAP LVT	Regional Directorate for Agriculture and Fishery of Lisbon and Tagus River Valley)
EDP	Electricity of Portugal
GPP	Office of Planning, Policy and General Administration
LVT	Lezíria do Vale do Tejo
EU	European Union

Figure 6.17: Key stakeholders for the Tagus agriculture's risk owners RMP (low precipitation)

6.3.1.4. Risk objectives, scope and criteria to evaluate the risk

The main goal in BINGO is to strengthen the economic agriculture sector by developing strategies for climate change adaptation in the lower Tagus under low precipitation (droughts) and estuarine floods. The way this broad goal is concretized in BINGO varies with the case study considered, as summarised in Table 6.5.

In the **two public irrigation perimeters** the risk assessment process has an objective directly related with the responsibilities and mission of the respective Irrigators Associations, the risk owners (management, conservation and exploitation of the public irrigation infrastructures). The scopes were focused according to BINGO context and objectives, and are the same in both cases. They intend to fulfil the farmer's expectations and the DGADR expectations, the national authority that supervises the public irrigation infrastructures.

Two of the respective specific objectives are similar, but a third one varies according with the specificities of each case study. In the Sorraia PIP it is related with its internal context, more precisely the infrastructures of water transport and distribution system, a complex of open channels, that have to be properly operated in order to deliver water in *due time*. On the other hand, in Leziria Grande PIP the different specific objective is related with its external context, regarding the *salinity* of the water at Conhoso intake. This is an issue directly related with the tide conditions within the estuary and the water resources management in the basin upstream of Conchoso water intake.

The Sorraia PIP will be subject of risk treatment both at research site level (sectoral Sorraia adaptation) as at governance improvement level. The LGVFX PIP will only contribute to water resources governance improvement, without site specific adaptation.

As previously referred, in **Lezíria do Vale do Tejo**, the risk identification scope is related with the water resources governance impacts in agriculture in Lezíria do Vale do Tejo, more specifically, with the identification of the water resources governance practices that may compromise irrigation during agricultural campaigns under extreme weather conditions (droughts).

The general objectives, scopes and specific objectives are presented in Table 6.5.

Table 6.5: Tagus RS - Objectives and scopes of the risk assessment processes of the Irrigation Associations and Farmers

RISK OWNER	OBJECTIVES	SCOPES	SPECIFIC OBJECTIVES	RISK CRITERIA	Risk Assessment extent			Risk Treatment	
				Function of:	Identificat.	Analysis	Evaluat.	Site specific	GOVERNANCE
ARBVS (Irrigators Association)	Assure efficient management, conservation and exploitation of the public irrigation infrastructures of the Sorraia Valley	Assure **supply of water demand** during agricultural campaigns under extreme weather conditions (droughts) (Fulfil needs and expectations of associated and beneficiary farmers)	Supply water **demanded**	**% Volume**: % (Volume supplied)/ (Volume demanded)	✓	✓	✓	**YES**	Water resources & Agricultural sector (water related issues)
			Supply water in **due timing**	**Timing**: Nº of day in delay (water delivery date – requested date)					
		Preserve the **integrity and operability of infrastructures** (Fulfil DGADR contractual expectations)	Achieve low levels of **water losses**	**% waters losses** (Water supplied / water abstracted)					
A**BLGVFX** (Irrigators Association)	Assure efficient management, conservation and exploitation of the public irrigation infrastructures of Lezíria Grande	Assure **supply of water demand and quality** during agricultural campaigns under extreme weather conditions (droughts) (Fulfil needs and expectations of associated and beneficiary farmers)	Supply water **demanded**	**% Volume:** % (Volume supplied)/ (Volume demanded)	✓	✓	✓	**no**	
			Supply water with **quality**	**Salinity**					
		Preserve the **integrity and operability of infrastructures** (Fulfil DGADR contractual expectations)	Achieve low levels of **water losses**	**% waters losses**: %(Water supplied / water abstracted)					
		Preserve the **integrity of agricultural lands** during extreme weather conditions (inundations)	Avoid inundation of agricultural lands	Volume of water that overtops dikes					
FARMERS of Lezíria do Vale do Tejo	Strengthen the agriculture economic sector in Lezíria do Vale do Tejo	Analyse **water resources governance** impacts in agriculture in Lezíria do Vale do Tejo	Identify the **water resources governance practices** that may compromise irrigation during agricultural campaigns under extreme weather conditions (droughts)	-	✓			**no**	

6.3.2 Establishing the external context

Agriculture is one of the economic sectors more strongly influenced by its external context within European Union. The Common Agricultural Policy (CAP) is one of the oldest policies of the European Union, being strongly rooted in the European integration project. It was created so that people could enjoy good food at affordable prices and farmers earn a fair living.

Due to the CAP's long history (since 1962), EU has adapted the CAP to the changing needs of society along time. In the 20th century it changed from market support to supply management to producer support to food quality. After 2000 the CAP focused on economic, social and cultural EU rural development. During the past decade and a half environmental concerns were also introduced and, more recently, climate change awareness and the inherent need for adaptation. In 2003 a relevant decision cut the links between subsidies and production, becoming more market oriented. Farmers started to receive an income support payment (decoupled from production), on condition that they look after the farmland and fulfil environmental, animal welfare and food safety standards. As market does not pay for these public goods (essentially good care and maintenance of soils, landscapes and biodiversity), the EU provides farmers with an income support to remunerate them for this service to society as a whole. This policy was further incremented in 2013, when CAP was reformed to strengthen the competitiveness of the sector, promote sustainable farming (now consider other natural resources as water and energy, as well as climate changes) and innovation and support jobs and growth in rural areas (European Union, 2014 c). All these changes correspond to three main phases: it brought Europe from food shortage to plenty; it changed and adapted to meet new challenges linked to sustainability and the environment; and it expanded the role of farmers in rural development beyond just food production (European Union, 2012).

The date that a Member State joined the European Economic Community (or more recently the European Union) is quite relevant for the agricultural context because it implied integration within the CAP, with a strong impact in the sector. Portugal integrated the EEC in 1986. Older and less educated farmers had hard difficulties in changing and adapting to a different new legal framework as well as to different producing practices and to more competitive markets. Some were also resilient to group in association. As a consequence, many of them stopped their economic agricultural activity and a significant decrease on agricultural land area was registered

in Portugal. On the other hand, agricultures that had the ability to seek for the new opportunities become much more modern and competitive.

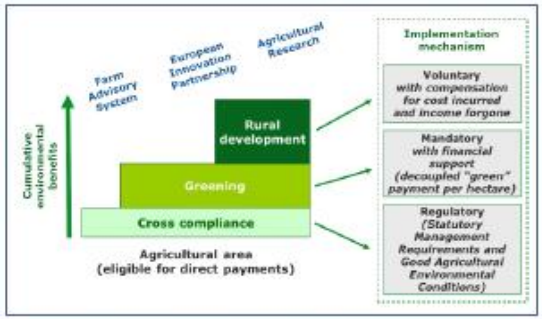
BINGO project is implemented along the 2014-2020 CAP polices, which broad objectives are: i) the environment (climate change and sustainable management of natural resources); *ii)* food security (double production at global level); *iii)* cohesion (looking after the countryside across EU and keeping the rural economy alive) and i*v)* protection of the Union's financial interests. The mechanism chosen to implement CAP objectives, as well as the respective legal framework, already integrate the relevant environmental and climate change concerns expressed in The Blueprint to Safeguard Europe's water resources. In particular CAP provides farmers with financial support to adjust their farming methods and systems to cope with the effects of climate change. CAP also allows now for variations among Member States in how it is used to support specific situations (flexibility framed by well-defined regulatory and budgetary limits).

The CAP should be seen by agricultures as opportunities to modernize and become more competitive, complying simultaneously with environmental sustainability concerns. Since 2003, agriculture is much more market oriented, therefore competitiveness is a very relevant issue and economic context becomes predominant in agricultures' decisions. The CAP need to be seen as an opportunity rather than a threat. The CAP has three dimensions: market support, income support and rural development, interconnected among them. Overall sustainability depends on the ability of the three dimensions to act collectively, what involves different levels of intervenient.

The BINGO climate change adaptation strategies for economic agriculture will be developed under this external context. Being most of farmers in the area already modern and competitive, a natural tendency exists to embrace further evolution and adaptation to become even more competitive. From the long-term CAP 2014-2020 objectives: viable food production; sustainable management of natural resources and climate action; and balanced territorial development, the two first objectives are the ones more directly related with the risk owners objectives established for the risk management process. To achieve the long-term goals for the CAP, the reform focuses on the competitiveness and sustainability of the agricultural sector by improving the targeting and efficiency of policy instruments. The external context affecting sectorial profitability and sustainability, as well as sustainable environmental management is summarised in Table 6.6, through PESTLE Analysis. For CAP 2014-2020 external context the following references were also used (European Union, 2013; European Union, 2014 a) 6 c); RDP, 2013).

Table 6.6: Tagus RS - External context for the RMP of Irrigation Associations and Farmers

<table>
<tr><th colspan="3" rowspan="3">PESTLE</th><th colspan="5">RISK OWNERS</th></tr>
<tr><th colspan="2">PUBLIC IRRIGATION ASSOCIATIONS</th><th colspan="3">FARMERS</th></tr>
<tr><th>ARBVS</th><th>ABLVFX</th><th>Inside Public perimeters</th><th>Private irrigation</th><th>Rain-fed</th></tr>
<tr><td>POLITICAL</td><td>Common Agriculture Policy (CAP)</td><td>Funding Mechanisms</td><td colspan="5">CAP 2014-2020 places the joint provision of public and private goods at the core of policy. The CAP has three dimensions: i) market support, ii) income support and iii) rural development, interconnected among them. It has a new architecture of direct payments; better targeted, more equitable and greener, an enhanced safety net and strengthened rural development. The new policy instrument of the first pillar (greening) is directed to the provision of environmental public goods, and constitutes a major change in the policy framework. The Rural development policy focuses on increasing competitiveness and promoting innovation.

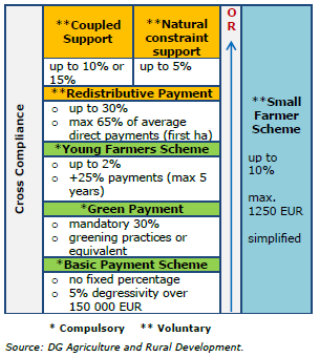
The new greening architecture of the CAP:
 

Source: DG Agriculture and Rural Development.

Actions targeted d under both pillars
<table><tr><th>PILLAR I</th><th>TARGETED ACTION</th><th>PILLAR II*</th></tr><tr><td>Green payment</td><td>ENVIRONMENT</td><td>Agri-environment-climate Organic, Natura 2000</td></tr><tr><td>Top-up payment</td><td>YOUNG FARMER</td><td>Business development grants Higher investment aid</td></tr><tr><td>Top-up payment</td><td>AREAS WITH NATURAL CONSTRAINTS</td><td>Area payments</td></tr><tr><td>Alternative simplified scheme</td><td>SMALL FARMER</td><td>Business development grants</td></tr><tr><td>Improved legal framework</td><td>PRODUCER COOPERATION</td><td>Aid for setting up producer groups Cooperation and short supply chain</td></tr></table>*Only main measures that target the specific issue under Pillar 2 are mentioned.
Source: DG Agriculture and Rural Development.</td></tr>
</table>

<table>
<tr><th colspan="3" rowspan="3">PESTLE</th><th colspan="5">RISK OWNERS</th></tr>
<tr><th colspan="2">PUBLIC IRRIGATION ASSOCIATIONS</th><th colspan="3">FARMERS</th></tr>
<tr><th>ARBVS</th><th>ABLVFX</th><th>Inside Public perimeters</th><th>Private irrigation</th><th>Rain-fed</th></tr>
<tr><td rowspan="2">POLITICAL</td><td rowspan="2">Common Agriculture Policy (CAP)</td><td>Pillar I - DIRECT SUPPORT TO FARMERS:

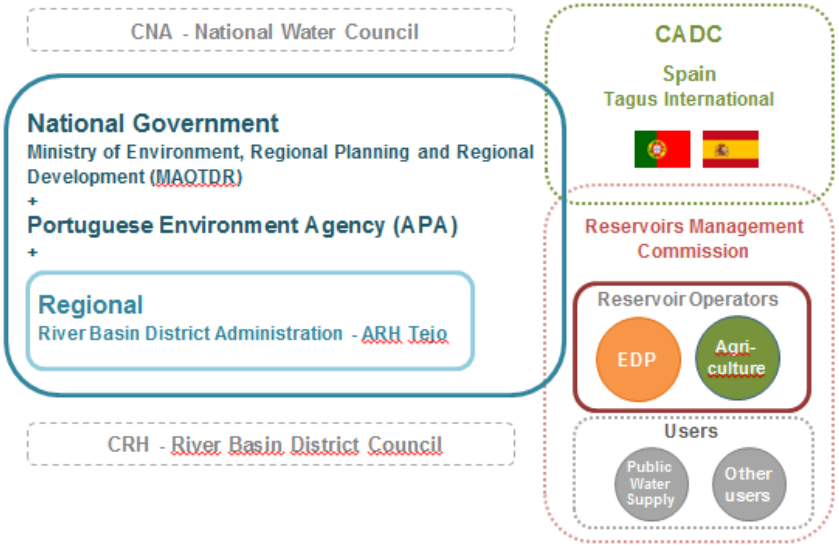
→ Basic Payment (requires cross compliance)

Regulation 1307/2013 | EP and Council, Dec.17, and related EU and National legislation);</td><td colspan="2">na</td><td colspan="3">• Income support for farmers and assistance for complying with sustainable agricultural practices: farmers receive direct payments, provided they live up to strict standards relating to food safety, environmental protection and animal health and welfare. These payments are fully financed by the EU, and account for 70% of the CAP budget. Under the June 2013 reform, 30% of direct payments will be linked to European farmers' compliance with sustainable agricultural practices which are beneficial to soil quality, biodiversity and the environment generally, such as crop diversification, the maintenance of permanent grassland or the preservation of ecological areas on farms.
Requires Cross-compliance:
- Statutory Management Requirements (SMRs).
- Good agricultural and environmental conditions (GAECs):
(Reg. (EC) 1122/2009 of the Commission, 30 Nov., and related EU and national legislation).
 

Source: DG Agriculture and Rural Development.
Promotes the implementation of good agricultural practices.</td></tr>
<tr><td></td><td colspan="2">na</td></tr>
<tr><td></td><td></td><td>→ Greening</td><td colspan="2"></td><td colspan="3">For properties larger than 10 ha - Contribution to specific environmental and territorial objectives.</td></tr>
</table>

PESTLE			RISK OWNERS				
			PUBLIC IRRIGATION ASSOCIATIONS		FARMERS		
			ARBVS	ABLVFX	Inside Public perimeters	Private irrigation	Rain-fed
POLITICAL	**Common Agriculture Policy (CAP)**	**Pillar II - <u>Rural Development Programme</u> (RDP 2014-2020)** (following the EC's decision - (2014) 9896 final, 12 Dec.	**Rural development measures:** intended to help farmers modernise their farms and become more competitive, while protecting the environment, contributing to the diversification of farming and non-farming activities and the vitality of rural communities. These payments are part-financed by the member countries, generally extend over a number of years, and account for some 20% of the CAP's budget.~ Funds earmarked for rural development can be used for both agricultural and non-agricultural activities, based on six priorities: • fostering knowledge transfer and innovation; • enhancing competitiveness; • promoting food chain organisation & risk management; • restoring, preserving & enhancing ecosystems; • promoting resource efficiency and transition to a low-carbon economy • promoting social inclusion, poverty reduction and economic development in rural areas. Individual countries or regions will also be able to draw up sub-programmes with higher support rates in order, for example, to address the needs of certain sectors facing specific situations, young farmers, small farmers, mountain areas and short supply chains.				
			RDP is the most relevant policy for irrigations associations. Previous programmes supported rehabilitation and modernization of irrigation infrastructures. PDR 2014 -20 provides financial support for further improvements.		• Support rehabilitation and modernization of irrigation infrastructures; • Other restructuring and modernisation measures; • Start up aid for young farmers; • Farm Advisory System; • training and innovation programmes		
		Market-support measures **Risk management**	na		EU level: → Market-support measures**:** these come into play in critical situations, for example, when adverse weather conditions destabilise markets. Such payments account for less than 10% of the CAP budget → Financial support to companies. National level: → Droughts - Resolution of the Portuguese Council of Ministers No. 37/2012, Mar. 27: i) Introduction of urgent measures regarding droughts; ii) creation of the Prevention and Monitoring Commission, iii) Monitoring Effects of Droughts and Climate Change → Agricultural insurance and other aid to help the damage caused by extreme weather events (Portaria n.º 42/2012, de 10 feb. and Portaria n.º 65/2014, de 12 mar. and other legislation)		
	Water Economy (under WFD)		Principle of recovery of the costs of water services as environmental "educator" policy				

<table>
<tr><th colspan="2" rowspan="3">PESTLE</th><th colspan="5">RISK OWNERS</th></tr>
<tr><th colspan="2">PUBLIC IRRIGATION ASSOCIATIONS</th><th colspan="3">FARMERS</th></tr>
<tr><th>ARBVS</th><th>ABLVFX</th><th>Inside Public perimeters</th><th>Private irrigation</th><th>Rain-fed</th></tr>
<tr><td>POLITICAL</td><td>Water Resources Management organization

In Portugal</td><td colspan="5">Tagus is an international river, heavily modified by damning, therefore affluences from Spain and water resources management (WRM) policies and practices in Portugal have influence in water availability and quality for irrigation.
WRM is also relevant in water pricing for agriculture and in extreme weather events management.
Water resources management structure in Portugal:
 

Legend:
CADC - Commission for the Implementation and Development of the Convention on Cooperation for the Protection and Sustainable Use of Luso-Spanish Water Watersheds
EDP - Electricity of Portugal
CNA - National Water Council (consultation body of the Portuguese Government)
CRH - River Basins District Councils (APA consultation and supporting bodies)</td></tr>
</table>

PESTLE			RISK OWNERS				
			PUBLIC IRRIGATION ASSOCIATIONS		FARMERS		
			ARBVS	ABLVFX	Inside Public perimeters	Private irrigation	Rain-fed
ECONOMIC	National Economic development/ state of the economy		na		The size and future development of Portugal's economic output will determine demand		
	International Economic development/ state of the economy		na		The size and future development of exportation countries 's either already existing or new opportunities due global Climate Changes		
	Production costs	RAW MATERIALS:	na		Changes Prices of seeds, fertilizers, pesticides etc. affect profitability		
		WATER PRICES: Cost of irrigation water	Costs supported by farmers		Introduction / changes in TRH (water resources taxes)		
		ENERGY PRICES:	Self-energy production makes the Association not very depend of market prices	Changes in the cost of energy used in water sourcing and transportation/ distribution for irrigation	Changes in the cost of energy used in water sourcing and transportation/distribution for irrigation		na
		LABOR COSTS			Political change of national minimum salary		
	Post-harvest prices		na		**EU Level:** CAP - a number of market instruments are used to provide market safety nets (http://ec.europa.eu/agriculture/markets/index_en.htm). The Common Market Organisation (CMO) sets rules which regulates agricultural markets in the EU, such as: parameters for intervening on agricultural markets and providing sector-specific support (e.g. for fruits and vegetables, wine, olive oil sectors, school schemes). It also includes rules on marketing of agricultural products (e.g. marketing standards, geographical indications, labelling) and the functioning of producer- and interbranch organisations. It also covers issues related to international trade (e.g. licenses, tariff quota management, inward and outward processing) and competition rules. CAP promote direct sale of food products, for instance via farmer's markets. **National Level:** - Market dimension and market price: Big supermarkets tend to lower products prices, - Transportation costs: can be an issue to consider		

PESTLE		RISK OWNERS				
		PUBLIC IRRIGATION ASSOCIATIONS		FARMERS		
		ARBVS	ABLVFX	Inside Public perimeters	Private irrigation	Rain-fed
SOCIAL	Private consumption	na		EU Level: - EU policies can affect demands or types of products being produced National Level: - The consumption decisions and lifestyles of individual affecting or shifting trends and fashions towards agriculture products consumption (in order to maximise their profits, producers tend to respond to market signals).		
	Industrial consumption	na		Changes in food processing mills: Leziria do Tejo has agro-food as significant consumers (ex: tomato). Changes will affect demand.		
TECHNOLOGICAL	Recent opportunities		- Energy production developments (solar or eolic) are opportunities to become less dependent from network supply	- Energy production developments (solar or eolic) are good opportunities to find efficient irrigation solutions in agricultural lands far from public energy network supply - New and efficient agrometeorological stations provide (by COTR, Agrotejo, …) easy and daily update information on irrigation needs promoting water use efficiency		

PESTLE		RISK OWNERS				
		PUBLIC IRRIGATION ASSOCIATIONS		FARMERS		
		ARBVS	ABLVFX	Inside Public perimeters	Private irrigation	Rain-fed
LEGAL European and National Legislation (Transposition into national legislation from EU Directives)	Economic and financial regime: WFD → Water law (Lei n.º 58/2005, 29 Dec.) and related legislation: a) principle of recovery of the costs of water services; b) the polluter-pays principle	a) principle of recovery of the costs of water services: TEC – taxes for maintenance and exploration of irrigation infrastructures and association services already existed prior to WFD: - Tax for maintenance of infrastructures - function of *area* of agricultural properties; - Tax to sustain association services, charging in function of *area* of agricultural properties or in function of volume supplied. Recovery of investments, although foreseen in Portuguese legislation, is not being implemented as political decision, due to the importance of the agriculture sector in Portugal.		a) principle of recovery of the costs of water services: **TRH** – Water resources tax as function of volume abstracted and services (lower prices within public irrigation perimeters)	a) principle of recovery of the costs of water services: **TRH** – Water resources tax as function of volume abstracted and services (higher prices outside public irrigation perimeters)	
	Environmental policies:	For farmers receiving direct support under CAP the following legal issues are already integrated in cross compliance. The other farmers should comply with the legislation, but lack of fiscalization that do not promote its implementation.				
	Biodiversity (Nature 2000): - Birds conservation - (79/409/CEE); - Habitats - 92/43/CEE	na		Biodiversity preservation		
	Water bodies protection: **- WFD 2000/60/CE** → Water law (Lei n.º 58/2005, 29 Dec.) and related legislation – **- Environmental liability** with regard to the prevention and remedying of environmental damage - *2004/35/CE;*	Water bodies protection (quantity)		Water bodies protection (quantity and/or quality)		
	Nitrates: Directive 91/676/CEE → Decreto-Lei n.º 235/97, de 3 de sep. and later updates	Require water bodies monitoring		In vulnerable zones the use of nitrogenous fertilizers is restricted, affecting productivity Require water bodies monitoring		

PESTLE			RISK OWNERS				
			PUBLIC IRRIGATION ASSOCIATIONS		FARMERS		
			ARBVS	ABLVFX	Inside Public perimeters	Private irrigation	Rain-fed
LEGAL	Fertilizers: **Regulation (EC) No. 2003/2003 of EP** → Decreto-Lei n.º 103/2015, 15 jun		Require water bodies monitoring		Enhance rational use Require water bodies monitoring		
	Pesticides: **Directive 2009/128/ EC** →Lei nº 26/2013, apr..		Require water bodies monitoring		Enhance rational use Require water bodies monitoring		
	Sewage sludge used in agriculture **Directive 86/278/CEE** → Decreto-Lei n.º 276/2009, 2oct		na		Control the way sludge can be used		
ENVIRONMENTAL	**Water availability** (changes in river flows, reservoir or groundwater's volumes for use in agriculture)		Volumes stored	Changes in precipitation pattern altering rivers flows	Changes in river flows or groundwater's availabilities		Changes in precipitation pattern
	Water Quality (changes harmful to:)	i) cultures		Salt water	Salt water		
				Nitrates	Nitrates (in vulnerable zones exist restrictions to nitrogen fertilization affecting productivity)		
		ii) irrigation systems			Macrophytes (ex: water hyacinths	Macrophytes	
		iii) final consumers:			Faecal contamination (for some types of cultures)		
	Climate Changes (changes in precipitation, temperature and extreme events' patterns in the agriculture region.)		Low Precipitation	Low Precipitation Surge storms	Increase in frequency and intensity of droughts, floods and storms		

6.3.3 Establishing the internal context

Out of the three agricultural sites addressed in BINGO, only the Sorraia Valley Irrigators Association (ARBVS) will perform a full risk management process. Therefore it was only established the internal context for this risk owner, which is presented in Table 6.7.

For the Irrigators Association of Lezíria Grande (ABLGVFX) and for the farmers of the Lezíria do Vale do Tejo only water resources governance issues will be addressed. Therefore the internal contexts, beyond the knowledge of respective water sources origins, are not very relevant. It was considered that characteristics referred in sites description (point 6.3.1.2) are sufficient to support water resources governance suggestions of improvement in work package 5.

Table 6.7: Tagus RS - Internal context for the RMP of the ARBVS

	Key Factors
GOVERNANCE & INTERNAL STAKEHOLDERS	Hierarchic structure chain: General Assembly; Association Direction; Technical staff. Decision responsibility → Technical staff Information collection responsibility → Field service team (Conservation and Exploration) Internal Stakeholders: Associated Farmers
GOALS & OBJECTIVES	1 - Assure supply of water demand and quality during agricultural campaigns under extreme weather conditions (droughts) (Fulfil needs and expectations of associated and beneficiary farmers): 2a - Supply water demanded 2b - Supply water in due timing 2 - Preserve the integrity and operability of infrastructures (Fulfilment of contractual obligations of concession by DGADR): Achieve low levels of water losses
STRATEGIES	**Successful Strategies** - Water apportionment strategy (Water allocation for each farmer decided in the beginning of agricultural campaign - march. In years of low reservoirs storage, apportionment to annual cultures depends on the water rights allocated in project or on the historical use of farmers. Exceptions to allocation restrictions are permanent cultures, like orchards). **Strategies that are not (so) successful**: Alternative cultures / Pause in activity **Strategies that are planned for the future:** i) Increase in quality of service to the farmer: - pressurization of the irrigation network; - build new weirs in the Sorraia and Almansor rivers; - adequacy of exploitation of hydropower plants to flows needed for irrigation. ii) Water use efficiency: - build a buffer tank, - pumping and reuse of lost flows; - rehabilitation of the irrigation network, - remote surveillance, iii) Ecologic measures: - rehabilitation and conservation of streams bed and banks.

	Key Factors
RESOURCES	**STAFF:** **Technical services:** 2 Agricultural engineers; 3 Technical engineers; 1 technician; 1 Environmental engineer **Conservation and Exploration:** 4 Irrigation Vigilantes; 32 Irrigation Menders; 5 Conservators; 6 Pumping station Operators; 2 Dam Responsible; 1 Cleaning assistant **Accounting and Administrative Services**: 1 Head of Administrative Services; 3 clerks; **Mechanic Services**: 2 mechanics; 6 machine operators; 1 truck Driver
	INFRASTRUCTURES: Maranhão dam and reservoir: - Total Capacity: 205,4 x 106 m^3 - Reservoir net storage capacity: 180,9 x 106 m^3 - Hydroelectric power: 7500 kVA Montargil dam and reservoir: - Total Capacity: 164,3 x 106 m3 - Reservoir net storage capacity: 142,7 x 106 m^3 - Hidroeléctric Central: 4000 kVA Magos dam and reservoir: - Total Capacity:: 3,38 x 106 m3 - Reservoir net storage capacity: 3,2 x 106 m^3 Gameiro dam: - Hydroelectric power: 1,36 0 kVA Furadouro dam: WATER DISTRIBUTION NETWORK – open channel flow (383 km): - Main channels – 112,9 km - Distributor channels – 98,5 km - Irrigation channels – 171,6 km
	EQUIPMENT: - 6 Irrigation pumping stations - 1 Irrigation and drainage pumping station - 4 Drainage pumping stations - 5 Irrigation reinforcement pumping stations - Constant level floodgate, irrigation modules and flowmeters - Heavy machinery park (transport vehicles and all-terrain; backhoes; crawler excavators and transport platform)

	Key Factors
RESOURCES (cont.)	**INFORMATION SOURCES** relative to: - annual volumes of water required for irrigation - through obligatory annual farmer register with individual estimates of water required for the following campaign - water storage; - infrastructure and equipment conservation status control
	TECHNOLOGY: Good: - irrigation optimization – through an agrometeorological network weather forecast Needing improvement: - water supply – presently flexible water supply by request, operated manually form upstream
	FINANCING SOURCES: - Exploration and Conservation fee, with two components per farmer: i) variable, as function of water volume supplied and ii) fixed, depending on the farm irrigated area - Community funds for some investments - Revenues from services to agriculture
	HYDROPOWER PRODUCTION using irrigation flows and surplus flows. Electricity generated is injected in public network (REN)
INTERNAL CULTURE	Age is NOT a problem within the ARBVS and the academic education is high. Access to knowledge and information and adaptation capacity does exist in ARBVS.

6.4. People and property safety - Trancão River Basin

6.4.1 Adaptation objectives within BINGO

The BINGO objective is to perform flood analysis (likelihood and consequences) and risk evaluation in the Trancão river basin, including preparing a list of structural and non-structural adaptation measures. So, the last phase of the RMP – risk treatment will not be developed in the scope of BINGO Project and, therefore, for the Trancão river basin system, there is no need for the identification of the risk owner neither for the establishment of the external context and the internal risk context.

6.4.2 System characterization

The Trancão river basin is located at the northern limits of Lisbon, covering an area of 279 km^2 heavily industrialized and densely populated. The Trancão river is 30 km long and flows into the Tagus estuary, near the upstream limit of the estuary (Figure 6.18). The climate is temperate with a dry summer season. The average annual rainfall is 836 mm (PGRHT, 2012).

From the 1960's, the proximity to the metropolitan area of Lisbon led to the urban and industrial expansion in the Trancão river basin, with construction works occupying floodplains with potential for agricultural development and housing on steep and erodible hill slopes. Urban, agricultural and industrial effluents have been discharged into the Trancão River and its main tributaries, the Loures and Póvoa rivers, and dramatically modified the region (Pinheiro *et al.* 1999). Since the 1990's the situation has been reversed with a series of interventions, namely the construction of wastewater treatment plants, the improvement of the drainage system and the rehabilitation of the riverbanks in the Trancão river mouth.

The Trancão River and its tributaries are prone to rapid floods due to intense rainfalls, steep slopes in the river basin headwaters and the existence of extensive urbanized areas. These flash floods cause high rates of soil and bank erosion, supplying large volumes of sediments and debris that clog narrow cross-sections of the river Trancão tributaries, increasing the water levels upstream and the flood hazard. In the historical flood events of 1967 of 1983, extensive inundations were observed, with overtopping of levees, that caused human casualties and severe social and economic impacts in most of the basin, particularly in Póvoa river and Loures lowlands. More recently, flood events were recorded in 1996, 2008 and 2012.

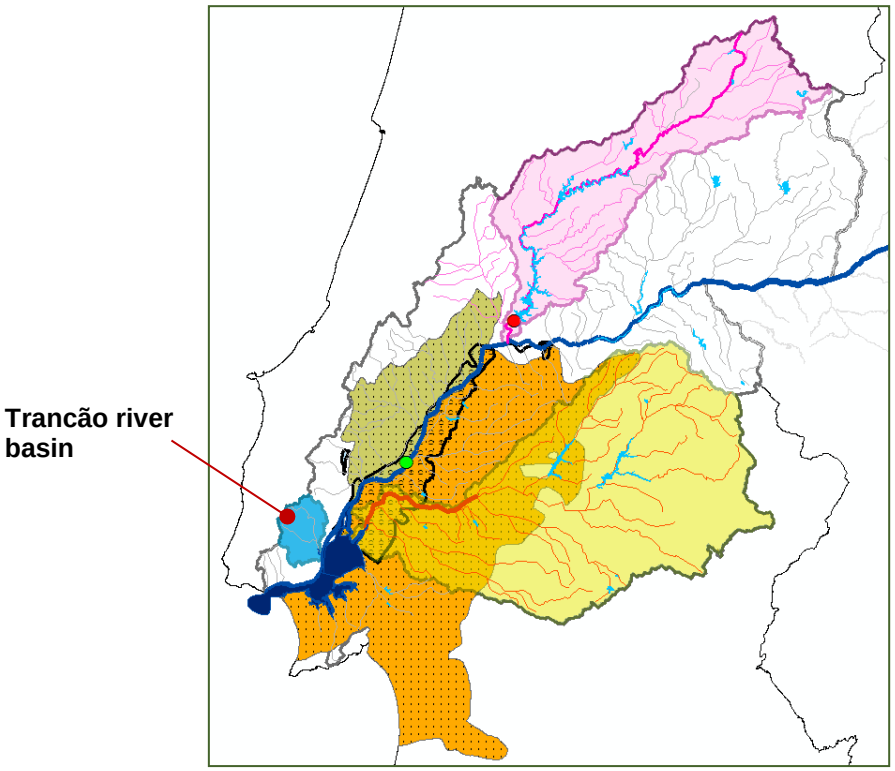


Figure 6.18: Tagus RS: Trancão River Basin

The potential for damage from floods in the Trancão river basin is mostly related to the rapid runoff response to intense rainfall events and the existence of roads and buildings constructed in flood-prone areas, and to constrains in the river channels. In response to frequent flooding, floods in the Trancão basin were studied in the past and several interventions were foreseen in the Regulation Plan of the Trancão river basin (HP, 1990), although they have not been implemented. Nevertheless, the importance of the flood risks in the Trancão river basin was recognized in the context of implementing the EU Floods Directive (Directive 2007/60/EC). Despite these efforts, flood damages in the Trancão river basin need to be estimated considering urban development and land-use decisions in a context of climate change in order to define and support appropriate flood management measures.

7 RMP CONTEXT AT BERGEN RESEARCH SITE

7.1. Identification of the risk management process of Bergen RS

The Norwegian research site, Bergen, is represented with two cases for which effects of climate change will be assessed. These cases relate to: 1) urban drainage and 2) public water supply (PWS). Climate changes that cause more extreme precipitation, stormwater amounts, CSO overflow and pollution to receiving bodies are of the highest concern in the city of Bergen. Thus, a full risk management process (RMP) will be performed for the Urban drainage sector. On the other hand, lowered water availability for drinking water supply in the future due to seasonal variations is also a threat. In the BINGO project, this will be addressed by risk identification and preparation of a general list of adaptation options for the PWS sector.

7.2. Sector 1: Urban drainage

7.2.1 Risk approach within BINGO

7.2.1.1. Adaptation Objectives within BINGO

The main BINGO CC objective is to manage the risk of more urban flooding and CSO due to climate changes. This involves to prepare the urban drainage system to avoid CSO during extreme precipitation events.

The RMP will involve the full risk assessment process: risk identification, risk analysis, and risk evaluation. Based on this, adaptation measures, both site-oriented and generic, will be proposed as risk treatment.

7.2.1.2. Research site description

In the city of Bergen 90% of the citizens are connected to public wastewater systems. The wastewater networks comprise 400 km of separate sewers, 400 km of separate stormwater pipelines and 400 km of combined systems. Parts of the pipelines are below seawater level, which leads to a significant infiltration of seawater into the system. There are 125 pumping stations, 300 CSOs, 1 chemical wastewater treatment plant and 5 mechanical treatments plants.

The major part of the combined system is located at the city centre areas and nearby sensitive water courses. Separation is therefore a high priority, to obtain less pollution

loss from the CSOs. An intensive program for network renewal is ongoing, with yearly investments in the order of 10-15 MEuro.

The urban storm water drainage is heavily affected by flash floods from the hills that surround the city centre. These intensive runoff incidents are frequent and lead to local floods and to combined sewer overflows near vulnerable receiving waters. The city will in coming years make large investments to improve the capacity of the wastewater system, partly by increasing the diameter of pipelines and partly by redesigning flood paths. There is a lack of knowledge on how climate change may be considered when designing the new storm water systems.

7.2.1.3. Identification of risk owner and key stakeholders

Bergen Municipality owns the infrastructures related to urban drainage and are responsible for the services provided. It is obligated by law to provide an adequate urban drainage. The Agency for Water and Sewerage Works is an agency of the municipality that have the necessary authority to govern all water services on behalf of the municipality. They are considered the risk owner in this study. The Municipality itself is thus a key stakeholder along with other departments and agencies of the municipality that are concerned with urban drainage. In addition to these internal stakeholders, the following external stakeholders have been identified to be relevant within the BINGO-project:

- Authorities such as Ministry of Environment, the National Hydrological Directorate (NVE), and District Governments (Fylkeskommunen);
- Bergen Vann (operator of both the drinking supply and the urban water collection system);
- Local housing groups/ Housing associations;
- Local action groups for improved /gentrification of inner city neighbourhoods.

7.2.1.4. Risk objectives, scope and criteria to evaluate the risk

The strategic objective of the Agency for Water and Sewerage Works is to prepare the urban drainage system to avoid flooding and CSO during extreme precipitation conditions. To succeed, the following specific objectives are defined:

- Protection of critical public infrastructure (e.g. main roads and railways, hospitals, parts of supply systems for energy, drinking water, sanitation systems
- Reduction of economic damages on private goods and properties
- Avoid impact on leisure activities (aquatic sports; bathing)

- Avoid impact in leisure activities (recreational activity at banksides)
- Avoid loss of production
- Avoid pollution from flooded industrial sites.

Table 7.1 provides and overview of the objective, their associated dimension (scope) and an indication of the what the risk criteria will be a function of in the full RMP.

7.2.2 Establishment of the external context

A PESTLE analysis is performed for Bergen Municipality with the aim of establishing the external context. The PESTLE analysis structures the information on external context in a political, economic, social, technological, legal, and environmental dimension. For Bergen Municipality, the political and economic context is well defined and detailed in BINGO deliverable 5.4. The key political and economic issues are: 1) how to incorporate CC in policies, and 2) the financing of CC adaptation measures, respectively. Specially 2), along with clarification of responsible actors, is an ongoing discussion in Norway.

In terms of legal (external) context Bergen Municipality is obliged to fulfil the Water Framework Directive, which incorporates the Bathing Water Directive and requires a regulated quality standard at the receiving waters. It is followed by corresponding environmental protection legislation at the national level and monitored by the county administrator, who is also and external stakeholder of the Bergen case in BINGO.

The analysis is summarized in Table 7.2. It should be noted that the external context will be further explored at the planned workshops with stakeholders of water resources in Bergen.

7.2.3 Establishment of the internal context

Governance and Internal stakeholders

In Bergen, the city council consist of 67 elected members that represent the political parties. The city government is elected by the city council and is divided into seven departments, which in turn are divided into sections and agencies. The city government operates at two decision levels (1 and 2). Departments and sections operate on decision level 1 and have a general responsibility for the municipality's politics and for guiding the agencies. The agencies operate on decision level 2 and are responsible for the actual services provided by the municipality. The aim of the two-level decision model is to provide sufficient responsibility and liberty to the managers and employees of the agencies.

Table 7.1: Bergen RS - Objectives and scopes of the risk assessment processes of Bergen Municipality

RISK OWNER	BINGO ADAPTATION OBJECTIVES	SCOPE	SPECIFIC OBJECTIVES	RISK CRITERIA: Function of
Bergen Municipality	Preparation of urban drainage systems to avoid flooding and CSO *during extreme precipitation conditions*	**Economic** (protection of economic activities)	Protection of critical public infrastructure (e.g. main roads and railways, hospitals, parts of supply systems for energy, drinking water, sanitation systems	- No. of items critical infrastructure flooded - Costs for reparation of damages (Euros)
			Reduction of economic damages on private goods and properties	Costs for reparation of damages (Euros) (e.g. reimbursements made by insurance companies)
			Avoid impact on leisure activities (aquatic sports; bathing)	EU standard for bathing
			Avoid impact in leisure activities (recreational activity at banksides)	Area of flooded fields
			Avoid loss of production	Nr. of days/hrs production downtime caused by flooding
		Protection of the **environment**	Avoid pollution from flooded industrial sites (industrial sites especially with dangerous materials)	EU standard
		Reputation and image	Avoid loss of trust in the municipality	- Customer satisfaction - Nr. of negative reports in media pr. year

Table 7.2: Bergen RS - External context for the RMP of the Bergen Municipality

PESTLE DIMENSION	RS KEY ISSUES	DETAIL
POLITICAL	Role of CC in policies	Taking into account programs and interests of political parties (EU, Norway, regional, municipal) as well as programs and interests of industry (lobbies). (Detailed in BINGO D5.4).
ECONOMIC	Costs occurring form damages caused by CC, costs for CC adaptation measures	Financing of CC adaptation measures, insurances, protections and payments, need for creation of new funding instruments. (Detailed in BINGO D5.4).
SOCIAL	Level of information and awareness of general public	Needs for information (communication concept).
TECHNICAL	Infrastructure/Technology development	Adaptation measures concerning observation and information/alarm, technical improvements, operational improvements, organisational improvements to meet water users targets
LEGAL	Regulation and legislation (EU and national)	The characteristics of National and European laws, directives and agreements that drive and influence policies regulating water cycle (i.e. Water Framework Directive, EU-Bathing Water Directive, Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks..
	Contracting	Ordinance and Statute, contracts with drinking water suppliers as well as with cities and municipalities.
ENVIRONMENTAL	Local CC-occurrence and impact on infrastructure	The changes in precipitation, temperature and extreme events patterns (magnitude of local CC, effects of CC on technical infrastructure).
	Quality and quantity targets	Definition of quality and quantity targets for different kinds of water use, which must be kept under CC (e.g. amounts of water for drinking water treatment, hydropower, agriculture, leisure activities and related quality standards or requirements).
	Water quality	The changes in water composition in terms of quality (pollutant load) and temperature.

The Agency for Water and Sewerage Works is under the Department of Urban Development and is responsible for: 1) supply and treatment of drinking water, and 2) disposal of sewage. The second responsibility involves stormwater collection and safe transportation. To secure urban drainage management in accordance with adaptation and risk objectives outlined in previous sections, the agency need to collaborate with other departments, sections, and agencies of the municipality. These internal stakeholders are:

- Section for Planning and Transportation (Department of Urban Development)
- Section for Civil protection and Emergency (Head of the City Government's Department)
- Section for Climate (Department of Climate, Culture and Business Development)
- Agency for Urban Environment (Department of Urban Development)
- Agency for Planning and Building services (Department of Urban Development)

Goals and objectives

The overall vision of the Agency for Water and Sewerage Works is: "Pure, clean water for all purposes" and their main goals include: maintaining a water supply that matches the demand, manage sewage and infrastructures in a sustainable and efficient matter, and maintain a high level of customer satisfaction. To achieve these goals, the following objectives are identified by the agency:

- Securing hygienic barriers in the water supply system
- Further develop transfer systems between the water treatment plants
- Reduce water consumption through leakage reduction in the supply network
- Securing the function of the supply network by planned maintenance, rehabilitation, and upgrades.
- Upgrade waste water treatment plants such that new treatment requirements are met
- Exploit the potential resources from sewage sludge for biogas production or fertilization.
- Correct and efficient processing of plans
- Maintain good customer relations and transparent communication

Environmental consideration is the guiding principle for goals, objectives and activities performed by the agency. Thus, they have defined the following metrics to be controlled and managed by the agency:

- The energy consumption in water treatment (plants and process)
- Environmental impacts of leakages from the sewage network and combined sewer overflows
- Damages caused by stormwater
- Discharge of contaminants on to the sewage network
- Discharge of sewage from waste water treatment plants
- Energy and chemical consumption in waste water treatment processes
- Environmental impacts from the construction of new infrastructure

Strategies

There are two strategic documents guiding the prioritization of activities of the agency: 1) Municipal master plan for water supply, and 2) Municipal master plan for sewage. These plans cover a 10-year period and are usually enacted for each planning period. They are evaluated every fourth year. Both the municipal master plan for water supply and sewage are considered successful strategic documents for prioritizing activities, however a clear strategy for stormwater management is not covered by these plans. Thus, a strategic stormwater plan is to be developed, preferably with input from the BINGO project. This governance gap is described in more detail in BINGO D5.4 *Report on the assessment of the current governance situation and recommendations for improvement at the research sites using the three-layer framework (part 1*).

Resources:

a) Staff

The Agency for Water and Sewerage Works is a large organization with over 80 employees and has good prospects of achieving the objectives.

b) Existing risk management expertise and practices

In terms of existing risk management and practices, an existing risk assessment **of stormwater** from 2005 will form the basis of the current work. Furthermore, the Section for Civil protection and Emergency (Head of the City Government's Department) has provided a general risk and vulnerability analysis which was enacted in the City Council in 2015.

c) Information sources

The municipality have systems where customers can report undesired events and conditions. They are currently working on a project which aims at engaging the population in reporting information on stormwater infrastructures (such as inlets).

d) Funding

The activities of the Agency for Water and Sewerage Works are funded by customer fees for water and wastewater services. The funding for stormwater management is not clear, but is currently being discussed. A recent Norwegian Official Report (NOU 2015:16) suggest an additional fee for this purpose, but responsibilities need to be clarified before implementation. This is described in more detail in BINGO D5.4 *Report on the assessment of the current governance situation and recommendations for improvement at the research sites using the three-layer framework (part 1).*

e) Infrastructures, technologies, and equipment

The relevant infrastructure is described in **previous sections**. In addition, the agency manages several meteorological stations and water **meters**. They also have models of the drainage system and flood maps. They are constantly working on improving these models.

Internal culture

Being the rainiest city in Norway, the agency has much experience on managing all the rain. They are currently working on upgrading and separating the combined sewer system and acknowledge the challenges climate change brings to this work. They also acknowledge the need for working interdisciplinary in the development of new strategies for stormwater management.

7.3. Sector 2: Public water supply

7.3.1 Risk identification approach within BINGO

The Agency for Water and Sewerage is, on behalf of, the Bergen Municipality and, according to the drinking water directive and corresponding legal acts, obliged to deliver a safe, reliable and good quality water supply. This is monitored by the Norwegian Food Safe Authority, who is also a stakeholder of Bergen case in BINGO.

For the public water supply (PWS) sector, a full RMP will not be performed. Instead, risk identification under CC scenarios will be performed with the aim of producing knowledge for latter application. A portfolio of indicative adaptation measures will be produced on the basis of the identified risks. The aim of this risk identification is to assist of the Agency for Water and Sewerage works with their strategic planning of water supply with the scope of assuring service continuity. The specific objective is to supply water in an adequate quantity.

As for the urban drainage sector, the Agency for Water and Sewerage Works is considered the risk owner and much of the external and internal context established in the previous sections are common for the two sectors.

7.3.2 Research site description

In Bergen, 97 percent of the total 270.000 citizens are connected to the municipal water supply. Five major treatment plants produce drinking water for the customers; Jordalsvatnet, Svatediket, Sædalen, Kismul and Espeland. While providing drinking water to a common distribution system, all the plants serve as backup for each other with a total regulated storage capacity of 26.5 mill m3. Furthermore, the structure of the systems allows for a non-fixed distribution pattern, where the plant operation may be optimized according to the water availability in the respective reservoirs, and the demand.

The water distribution network contains 900 km of water mains, 62 dams and 30 balancing reservoirs constituting a total capacity of 223.000 m3, equal to 2 days' demand. Recently the utility improved the storage capacity.

In the master plan (2014-2023), the utility argues that their current actions on leakage detection and water main renewal are likely to decrease the leakages to 20% in 2040 (from 30% today). Moreover, they emphasize the current facilities´ ability to deliver adequate amounts of drinking water for several decades ahead. At the same time, the population in Bergen is estimated to grow steadily until 2040 (SSB2014) and the connection degree is assumed to increase to 98% by 2020.

In 2010 Bergen suffered a longer drought event that initiated major preparedness at the water utility and illuminated that drinking water reserves are in fact vulnerable to climate change. The water supply system in Bergen differs from the typical Norwegian and European systems in the way that its basins are widely distributed across the region. It is designed based on stable precipitation in frequency and magnitude. As the rainiest city in Europe, historically, few issues have been reported related to quantitative shortages in the water reserves. However, the system comprises of relatively small and fully exploited drinking water reservoirs. Even though the reservoirs are aligned, the risk for inadequate capacity is present during periods of reduced precipitation. Until recently, little effort has been laid down in assessing the hydrological behaviour of the catchments connected to water.

8 RMP CONTEXT AT BADALONA RESEARCH SITE

8.1. Risk approach within BINGO

Badalona is the Spanish Research Site selected in the framework of BINGO project to assess the effects of climate change (CC) on flooding and pollution of the receiving water bodies related to combined sewer overflows (CSOs). The first one concerns people safety and economic impacts on goods and properties during flash floods due to intense precipitations in urban areas. The other one focuses on the pollution of the receiving water bodies in case of sewers overflows during heavy and moderate rainfall events, which has potential consequences on people safety, reputation and image of the municipality and significant impacts on tourism and economic activities.

8.1.1 Adaptation Objectives within BINGO

The BINGO CC adaptation objective is to increase the urban resilience respect to floods and CSOs problems in a context of CC applying several advanced concepts in the urban drainage management.

The extend of the RMP for both, urban drainage system and receiving water bodies, will cover the three steps of CC risk assessment (risk identification, analysis and evaluation) and the risk treatment phase. Adaptation measures will be defined (in WP5) in close cooperation and co-production with the risk owner and the main stakeholders involved.

8.1.2 Research site description

Badalona is located in eastern Catalonia (Spain) and is part of the Barcelona metropolitan area. It is situated on the left bank of the Besòs River and on the Mediterranean Sea, backed by the Serra de la Marina mountain range. With 220.000 inhabitants, Badalona is the third most-populated municipality in Catalonia. The morphology of its catchments is characterized by high gradients (with an average of 4%) in the upper part of the cities and very flat areas in the down cities (See also Deliverable 3.1 “Characterization of the catchments and the water systems” for more specific information).

Typical rainfall events with high intensity during short durations that take place during autumn and spring periods over this geographical location facilitate urban flash floods in several critical points with significant economic damages and high hazard conditions for pedestrian and vehicular circulation.

Regarding environmental issues, Badalona presents 5 km of beaches with a significant impact on the tourism of the city. During rain events, part of stormwater (from the more than 15 points with potential CSOs) not entering into Wastewater Treatment Plants (WWTPs), generates CSOs with significant social and economic damage related to the inability of bathing waters (Figure 8.1 and Figure 8.2).

Figure 8.1: On the left consequences of flooding problems during one of the last heavy storm event. On the right, CSOs impact in Badalona bathing waters.

Les platges de Badalona, tancades per la insalubritat de l'aigua

Les tempestes d'aquest divendres van arrossegar aigües residuals al mar

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Figure 8.2: The beaches of Badalona closed due to the insalubrity of bathing waters (Source: ARA newspaper, 23 of July of 2016. Web: http://www.ara.cat/societat/platges-Badalona-tancades-insalubritat-laigua_0_1618638313.html).

Concerning flash floods in the urban area, risk assessment, and specifically hazard evaluation for current and future scenarios will be based on a further development of a hydrologic and hydraulic model of the Badalona urban drainage system (See also Deliverable 3.1 “Characterization of the catchments and the water systems” for more

specific information). The base of this model was developed during the elaboration of a drainage master plan (DMP) of the city that was carried out in 2012 in order to analyse the current deficiencies in structural and functional terms of the sewer system.

As a result of this analysis, significant problems were detected during field visits (Figure 8.3), such as:

- Sedimentation along pipes.
- Poor state of conservation.
- Not enough capacity because of inadequate pipe sections.
- Not enough street inlets.
- Several CSOs into bathing waters.

Figure 8.3: Sedimentation and structural problem in the Badalona sewer network.

This DMP also proposed adequate measures to mitigate flooding and CSOs problems. Specifically the main strategy proposed was the construction of stormwater tanks and the proper monitoring of the network. Although clear benefits are offered by the construction of these structures along the network (floods and CSOs can be drastically reduced), a big investment is required to construct and operate these infrastructures. To date, only one of those storm water tanks was constructed and is already operating. This is the Estrella tank with a total storage volume of 33,000m^3.

At the same time, the sewer network is also monitored through a system formed by a wide number of water level and rain gauges that will be upgraded in the context of BINGO.

8.1.3 Identification of risk owner and key stakeholders

Badalona is part of the Barcelona metropolitan area. Different institutions are involved in the urban drainage management of the city and the related consequences in case of failures generating flooding and pollution of the receiving water bodies. These institutions are Badalona municipality, the Barcelona Metropolitan Area (Àrea

metropolitana de Barcelona, shortly AMB) and the mixed Company Aigües de Barcelona.

Badalona municipality is the entity in charge of the municipal sewerage system (green pipes in Figure 8.4), whose mission is to ensure the maintenance operation of the drainage network in order to guarantee its correct functioning. It is also responsible for the cleaning operation of the network and for forbidding the bath in Badalona beaches in case of pollution of bathing waters. Hence, Badalona municipality is the risk owner of the research site.

Municipal sewerage system connects with the supra-municipal urban drainage system (red pipes in Figure 8.4), whose responsibility lies in the **AMB and "Aigües de Barcelona",** as companies in charge of interceptor and Wastewater treatment plant (WWTP). Both entities plays the role of **key stakeholders** in the BINGO framework and specifically in context of the RMP.

Figure 8.4: Badalona sewer network (green) and metropolitan area of Barcelona (AMB) network (red).

8.1.4 Risk objectives, scope and criteria to evaluate the risk

The main risk objective which Badalona municipality has to accomplish, as risk owner in BINGO framework, is the preparedness of urban drainage systems during moderate and extreme precipitation for the reduction of flash floods in urban areas and CSOs affecting beaches.

In this regard, different scopes are considered in Badalona Research Site. The risk scope includes people's safety and economic issues regarding the impacts due to direct and indirect damages on goods, properties and economic activities or the adverse consequences of flooding and CSOs due to climate change.

1. **Potential consequences of flooding in Badalona due to climate change**

Significant changes have been implemented in Badalona sewer network during the last years, even so, the current scenario shows a few number of flood prone areas that could be increased due to CC effects with potential consequences on people' safety and economic direct and indirect losses. In this framework, two specific goals have been selected in BINGO.

These goals consist on minimizing flood risk for people and vehicles during heavy storm events and to minimize direct and indirect economic damages on goods and properties.

2. **Potential consequences of CSOs in Badalona due to climate change**

Since the publication of specific legislation regarding bathing waters: 2006/7/CE and the RD 1341/2007, public administrations have been providing big effort in order to manage the quality of bathing waters, with a special focus on sewer system overflows. These overflows cause episodes of short term water contamination which may affect the quality of bathing waters with clear consequence on human health and safety and, in terms of economic losses, on the tourism and more generally leisure sector.

In fact, during CSOs events, people can get in contact with polluted water (mostly enteric pathogens)- causing waterborne diseases), or the floodwaters provide breeding grounds for vectors such as mosquitoes that can transmit them.

According to the existing European and Spanish laws, Badalona municipality (as a decision-maker) must forbid bath when bacterial levels (E.Coli or Enterococcus) does not accomplish the cited standards. In these cases, tourism and several activities related to leisure are directly affected with significant economic losses.

In order to prevent this situation, major effort should be done to improve water quality during moderate and heavy storm events reducing CSOs on the receiving bathing waters.

Table 8.1: Badalona RS - Objectives and scopes of the risk assessment processes of Badalona Municipality

RISK OWNER	OBJECTIVES	SCOPE	SPECIFIC OBJECTIVE	RISK CRITERIA
Badalona Municipality	Preparation of urban drainage systems to reduce flash floods *during extreme precipitation events*	**People safety**	To minimize flood risk for people and vehicles during heavy storm events	% of area classified as moderate or high hazard according the vulnerability criteria defined.
		Economic	Reduction of direct and indirect economic damage on goods and properties	Expected Annual Damage (EAD) Flood damages for 10 years of return period with CC
	Preparation of urban drainage systems to reduce CSOs impacting bathing waters *during moderate and extreme precipitation*	**Public safety**	To minimize risk for people due to the contamination of bathing waters during and after moderate and heavy storm events	% of km of beach whose bathing water presents high bacterial contamination according to EU bathing water directive thresholds.
		Reputation and image	Avoid loss of trust in the municipality	Number of days of non-compliance of the EU bathing water directive (bathing forbidden and beaches closed) in a representative bathing season.
		Economic	Reduction of economic impacts on tourism, fishing and leisure sectors due to CSOs.	Tangible indirect damages (expressed in Euros).

8.2. Establishment of the external context

As explained at the section 8.1.3, the city of Badalona is part of the Barcelona metropolitan area, so there are different institutions involved in its drainage management and the related consequences in case of failures generating flooding and pollution of the receiving water bodies.

Each stakeholder takes an important role within BINGO context and is an official partner in Badalona research site. For this reason, a short description of these institutions has been developed in the following section, highlighting their functions.

PESTLE analysis has been done defining political, economic, sociological, technological, legal and environmental external framework. In the field of legal context, a list of national standards and protocols has been provided. It should be noted that most of them refer to environment and the related need to improve water quality of receiving bodies. Another important aspect is the lack of a specific legal framework concerning CC and the relative pressures on water and physic systems.

Depending on the flood risk level of each municipality (defined in INUNCAT[5]), the creation of a Municipal Action Program (PAM) is set as compulsory (very high, high or medium flood risk), recommended (moderate risk) or not needed (low flood risk). Most of the municipalities (520 out of 946) of Catalonia (including Badalona with a high risk level), must have a PAM for flood events.

The Spanish Royal Decree RD903/2010 derived from the Floods Directive 2007/60/EC, in its scope, excludes pluvial and sewer flooding. Furthermore, the first Flood Risk Management Plans carried out by the Catalan Water Agency only concerned the main Catalan rivers and did not treat short and ephemeral water courses (like the “Rieras” of Badalona) notwithstanding the high risk related to their hydraulic behaviour.

[5] GENCAT, 2006. *Pla d’emergència per inundacions – INUNCAT*, Departament d’Interior de la Generalitat de Catalunya, _Relacions Institucionals i Participació. Barcelona, Spain: Generalitat de Catalunya.

Table 8.2: Badalona RS - External context for the RMP of Badalona municipality

PESTLE Dimension	RS KEY ISSUES	DETAIL
POLITICAL	• Several actors involved in the urban drainage management (Badalona municipality, AMB, Aigües de Barcelona). • Badalona municipality and AMB (through Aigües de Barcelona) manage different infrastructures, so a good coordination between them is required.	- The integration of different drinking water utilities into one public-private company has greatly improved the management of the whole water cycle in the metropolitan area. However, better coordination between Badalona's stakeholders for wastewater management is required. - There is still a lack of a specific legal framework concerning CC and the relative pressures on water and physic systems. Drainage Master Plans (DMP) seems to be the proper tool to assess future scenarios in the sewer network. Other local initiatives are taking place in Badalona, such as Municipal Action Plans (PAM), where Municipality and citizens work together to analyse current weaknesses and study the proper solutions. - In Deliverable 5.4 "Report of the assessment of the current governance situation and recommendations for improvement at the research sites using the three layer framework" an extended explanation is offered.
ECONOMIC.	• Flood and CSOs consequences can be translated into economic costs which must be assumed by the authorities, citizens or insurances companies. • Apart from the own citizens of Badalona, specific sectors and urban services like tourism, transport, etc. could suffer climate change effects.	- Direct and indirect damages related to flooding - Indirect damages related to CSOs on tourism sector and generally on fishing and leisure activities - Interest rates and GDP are key factors to estimate direct and indirect damages for future scenarios
SOCIOLOGICAL	• CSOs into bath waters disrupt several summer activities. • After every storm event has happened, water managers' image is devaluated. Moreover, it calls into question the managers' competence.	Mediterranean citizens have an extended tradition in terms of drought during summer after long periods without storm events. Their consumption of water, at least for metropolitan inhabitants, is 109.5 l/inhabit per day. It is quite low compared with other European capital cities (Barcelona city council, 2012)[6].

[6] Barcelona Data Sheet 2012. Economy, Business and Employment Area. Barcelona City Council. Webpage: http://barcelonacatalonia.cat/b/wp-content/uploads/2012/12/datasheet-2012-angles.pdf

PESTLE Dimension	• RS KEY ISSUES	DETAIL
TECHNOLOGICAL	• DMP is a key tool in order to make a diagnosis of the current state, the prediction of future scenarios and the proposal of economically valued solutions. • Early Warning System (EWS) for flooding and CSOs events	- Diagnosis and prognosis provided by DMP - Proposed solutions in the DMP (like the construction of Estrella retention tank) - Implementation of an EWS for flooding and CSOs events on the basis of a monitoring system
LEGAL	• Current legislation applies for the protection of both citizens and the environment. • More funding is required to implement all the demanded measures.	- RD 11/1995 (derived from 91/271/EEC) Protection of the inland and sea water quality from adverse effects of urban wastewater discharges. - RD 509/1996 (derived from 91/271/EEC) Establishment of wastewater treatment rules. - RD 1341/2007 (derived from 2006/7/EC) Establishment of the bath water quality management. - RD 1290/2012 (derived from 2000/60/EC) Establishment of the improvement and regulation criteria of CSOs and SSO in wet weather. - RD 817/2015 (2006/60/EC, 2008/105/EC) Establishment of the monitoring and evaluation criteria of surface water and environmental quality rules. - INUNCAT, GENCAT, 2006 (2007/50/EC) Catalan flood risk management plan.
ENVIRONMENTAL	• Despite the big uncertainty on CC, an increment of flooding and CSOs into bathing waters could be possible. • Water quality and water resources preservation • Land uses characterization	- Climate and weather changes could increase flooding and the CSOs on the receiving bathing waters

8.3. Establishment of the internal context

1) GOVERNANCE & STAKEHOLDERS

In the urban drainage management, Badalona municipality works together with metropolitan authorities: Barcelona Metropolitan Area (Àrea Metropolitana de Barcelona, AMB) and the water company Aigües de Barcelona. All of them are involved in the BINGO project as stakeholders. Following a short description of these stakeholders is provided:

- **AMB** is the public administration of the metropolitan area of Barcelona which includes the Badalona Research Site. The competences of the AMB are related to territorial planning, transport and mobility, urban development and housing, environment and water cycle, economic and social development, and finally, social and territorial cohesion. The AMB is the owner of the main urban drainage infrastructures (interceptors, metropolitan pipes, etc.) and coordinates them with the local sewer network and Waste Water Treatment Plants (WWTP).
- **Aigües de Barcelona** is the company that manages the metropolitan service of the integral water cycle, which includes: water supply, sewerage and wastewater treatment and re-use water systems. Moreover, it is in charge of the operation and management of the WWTP affecting the Badalona Research Site.

  Nowadays, it works as a public – private company because it is participated by AMB.

Furthermore, a key role is played by Aquatec. It is the private company in charge of the maintenance and the exploitation of the sensors and the control centre of the drainage network of the Barcelona metropolitan area, including Badalona and coordinates all the tasks concerning Badalona research site. The company, main partner in the BINGO project, counts on a specific unit (Urban Drainage Direction) fully dedicated to urban drainage with 24 employers with high professional qualification in this sector.

Other important stakeholder is the Catalan Water Agency (Agència Catalana de l'Aigua, ACA). ACA is the responsible of the regional catchments and their water courses. In Badalona, ACA is the risk owner of the potential flooding problems related to ephemeral water courses.

Moreover, Badalona harbour plays an important role for social and economic aspects (tourism sector, water sports, specific activities related to fishing and moored vessels,

etc.), so port authority is another important stakeholder to be considered in this research site.

Finally, a lot of people living in Badalona are potentially affected by flooding and CSOs problems during moderate and severe storm events. Depending on the flood prone areas, some districts and their related inhabitants are most exposed to flood consequences.

2) GOALS & OBJECTIVES

Due to the interaction between the three institutions mentioned before, integration and coordination of policies and management are strongly required. The common principles concerning this type of strong collaboration and the risk criteria are in Table 8.1.

3) STRATEGIES

a) Successful Strategies:

Several departments compose Badalona municipality[7]. The environmental and sustainability department aims to make compatible economic development and urban growth of the city and preserve the environment of Badalona. It is very aware of the CC consequences. The strategies that are followed by the municipality are:

- Use of solar energy in several municipality buildings[8].
- Environmental education at school.
- Data collection of the most common environmental indicators. Such as waste, mobility, energy consumption, greenhouse gases, air and water quality, etc.
- Tracking the criteria of Agenda 21.

Agenda 21 is a program proposed in the Summit of Earth of the United Nations that took place in 1992. It refers to sustainable development. In this framework, the city council realise the Municipal Environmental Audit through the Environmental Forum:

The Municipal Environmental Audit consist on different phases:

- Weakness assessment of the city
- Elaboration of a Municipal Action Plan (PAM) in order to correct these weaknesses and

[7] The administrative organization can be consulted in the Badalona municipality web page: http://badalona.cat/portalWeb/badalona.portal?_nfpb=true&_pageLabel=contingut_estatic&dCollectionID=1182#wlp_contingut_estatic

[8] Solar panel installation are presented in the following web page: http://www.xarxasolar.net/badalona.php

- Monitoring of the PAM in accordance to different indicators.

The Environmental Forum is an advisory and participatory body in accordance with the provision of the Municipal Law. Its functions are:

- Identify environmental problems and sources of pollution
- Define objectives and priories the correspondent actions
- Examine and assess the situation concerning the preparation of the Badalona's Environmental Audit.
- Encourage citizens in the elaboration process of the audit.
- Promote activities to study sustainable development models.
- Disseminate the environmental education activities.

This body is directed by the mayor of Badalona and it is composed by other municipality representatives, local groups, trade unions, political parties, organizations, associations and federations[9].

b) Strategies that are not (so) successful:

Communication between local stakeholders and citizens and local actors no apparently directly involved in the urban water cycle.

c) Strategies that are planned for the future:

Several strategies are planned together with the different stakeholders. These strategies have been discussed in the second local workshop organized in the BINGO framework.

The detail of these strategies is compiled in the Deliverable 5.1 "Portfolio of risk management and adaptation measures available for the six research sites in BINGO".

4) RESOURCES

Local stakeholders provide the following resources summarized in the Table 8.3 to reach the mentioned objectives.

[9] For detailed explanations its web page can be consulted: http://badalona.cat/portalWeb/badalona.portal?_nfpb=true&_pageLabel=contingut_estatic&dDocName=AJB074987#wlp_contingut_estatic

Table 8.3: Description of resources available to the risk owner and stakeholders needed to support the organizational objectives.

<table>
<tr><th></th><th colspan="2">AMB</th><th>AIGÜES DE BARCELONA</th><th>BADALONA MUNICIPALITY</th></tr>
<tr><td>Staff characteristics</td><td colspan="2">The mixed company (public-private) has 7 people that directly manage the urban drainage in Badalona:
- 3 heads of management, maintenance and service of sewerage an re-use networks
- 2 inspectors of network maintenance.
- 2 people involved in generic task.</td><td></td><td>The municipality has 15 employees with 4 fully prepared vehicles doing the cleaning tasks of the 4 beaches existing in Badalona along the year, and a boat that collects the floating solids during the bathing season.
Municipality has also subcontracted the operation, cleaning and maintenance of the sewer network to an external company that dedicates significant resources in terms of equipment and employers to these tasks.</td></tr>
<tr><td>Risk Management</td><td colspan="4">Municipal Action Plan for flood events and specific protocols in case of CSOs.</td></tr>
<tr><td>Information resources</td><td colspan="4">1 operative control system collecting, managing, analysing and providing data and information
Official website with strong direct relation with customers</td></tr>
<tr><td>Funding</td><td colspan="4">Water rate and metropolitan tax on waste management</td></tr>
<tr><td rowspan="2">Infrastructure, technologies and other equipment

The infrastructures of AMB and Aigües de Barcelona offers service to all the municipalities of Barcelona Metropolitan area</td><td>1 desalination plant
7 wastewater treatment plant
4 re-use water plants and network
10 water treatment plant
63 supplying manholes
1 lamination pond
2 water retention tank</td><td>1 operative control system based on a wide set of sensors (rain gages, water depth sensors, etc.)
2 water treatment plants
99 water reservoirs
94 Pumping stations
+300km of pipes
4 submarine outfalls</td><td rowspan="2">318 km of sewer network
1 water retention tank
Sediments traps
1 water quality laboratory</td></tr>
<tr><td colspan="2">Of all of these infrastructures 1 pumping station, 15km of pipes and Besòs wastewater treatment plant are giving service to the Badalona Sanitation system.</td></tr>
</table>

5) INTERNAL CULTURE

Although the municipality have invested an important part of its budget in order to assess the climate change effects in terms of water scarcity, there is no responsible culture related with sanitation. A long way exists in order to introduce the idea that sewer networks are not landfills where rubbish disappears. Furthermore, there is no awareness that these rests are cause of problem within the sewer network (blockages, water quality, etc.) and they increase the adverse consequences on receiving waters.

A good effort must be carried out with regard to these aspects in order to mitigate the effects of the climate change and preserve the natural valuated spaces of the beach. Hence, governance should be re-thought by providing new policies considering anticipatory measures, together with the necessary funding framework.

9 SUMMARY OF THE RMP CONTEXT AT THE BINGO RESEARCH SITES

9.1. Introduction

From the six research sites (RS) of BINGO, three are located in the northern Europe (Bergen city, Norway; The Veluwe, Netherlands and Wupper basin, Germany) and three in the southern Europe (Badalona, Spain; Troodos mountains, Cyprus and Tagus basin, Portugal). Although having different mean annual and seasonal temperatures and precipitations, all sites are facing extreme weather events associated with both low and high precipitation.

Work package 4 (WP4) has as objective within BINGO to assess the impacts of extreme weather events on water-related human activities. For general overview purposes of what this WP is addressing a brief reference to each research site concerns and its adaptation objectives in BINGO is provided in the following subchapter.

In the following subchapters a summary of the most relevant items of the context for the risk management process are presented. In Annex II some tips to implement work packages 4.2 and 4.3 are provided.

9.2. General overview of BINGO research sites

9.2.1 *Brief research sites description*

Wupper, Germany

A mid-size river catchment, the Wupper river basin has an area of **813 km²**. It is a strongly industrialized region, ranging over several municipalities, with a population of **950.000 people**.

Wupper Association (WA) has the responsibility for water management within the catchment area. It operates an extensive multipurpose system, including twelve reservoirs, eleven wastewater treatment plants, numerous stormwater tanks and flood control reservoirs. It is a public body that performs its tasks in a wide range of water uses: water supply provision, wastewater treatment, flood protection, together within the maintenance and ecological development of the rivers and streams, and has a wide range of associated members: town councils, local and district authorities, municipal water suppliers, effluent disposal businesses, and trade and industrial organizations.

Risk addressed problems: Flash floods increase, extreme dry periods, ecological impacts and availability of water for different uses. *Management of Wupper water resources* to face both types of extreme weather events is the central adaptation issue of in BINGO.

The Veluwe, Netherlands

Veluwe aquifers and streams function as water source for **1.250 km^2** of reserve area, which ranges over several municipalities and serves as an important area for nature and recreation. Around 80% of the Veluwe area is covered by natural vegetation. The system has up to 20 or 30 small stream valleys and springs and is totally dependent on **groundwater**. Subsoil contains a large reservoir of fresh groundwater that is exploited for the production of drinking water for the consumption needs of **two million people**.

Risk addressed problems: Climate projections anticipate precipitation shifts from summer to winter and an increase in potential evapotranspiration during summers, meaning that dry spells will occur more frequently and intensively. As a consequence, the importance of the Veluwe for drinking water production will increase. This last, together with the increasing need for fresh water for agriculture, recreation and groundwater dependent habitats and aquatic life in small streams and the overall management of natural vegetation at the Veluwe will lead to conflicts. *Management of the Veluwe groundwater* and adaptation of *Public water supply utility (Vitens)* under climate change is the adaptation purpose in BINGO.

Troodos, Cyprus

The Cyprus research site is located along the northern steep slopes of the Troodos Mountains in Cyprus, which form the "water tower" of the island. The northern slopes are in the rain shadow of the mountains and are less endowed with water resources than the southern slopes. **A small river basin catchment**, Peristerona watershed presents a drainage area of **112 km^2**, with agriculture as the most relevant economic activity in the region. The Peristerona Watershed's communities covered 3.273 ha in 2010. The local population in the communities is approximately **5.000 inhabitants.** Domestic water supply is managed by the local community councils, and is exclusively based on **groundwater**. Other small catchment, **Pedieos Watershed** (120 km^2) is prone to flash floods in urban areas.

Risk addressed problems: the northern slopes of the Troodos have potential for being effected by climate change, impacting the southern slopes. The main objective in **Peristerona Watershed** is to develop adaptation strategies to sustain the two main water uses in dry years: *agriculture and domestic water supply*, and to identify the *flash flood hazard* in the urban areas of **Pedieos**.

Tagus, Portugal

The Portuguese research site is located in the lower Tagus river basin, a **large international river catchment**, with an area of 80.600 km² and different land uses. Climate change adaptation is focused on two key sectors, one concerning public water supply and the other concerning agriculture, one of the most relevant economic activities in the region. Inundations due to flash floods or storm surges are also a concern.

The **public water supply utility** addressed in BINGO is EPAL that supplies almost 3 million people of Lisbon city and surrounding 35 municipalities of the right margin of the river Tagus. EPAL doesn't hold private water sources and is dependent of surface and groundwater resources shared with other users. Water resources governance dependence is a key issue for EPAL.

The **agriculture sector** in BINGO is focused on two different realities, public irrigation perimeters of the left lower margin of Tagus river (Sorraia Valley - 15365 ha and Lezíria Grande de Vila Franca de Xira - 13420 ha), with irrigation infrastructures funded by the government, the former holding storage capacity and the latter no, and the remaining region of Lezíria do Vale do Tejo, where intensive irrigate agriculture is practiced, but irrigation infrastructures are private. Water resources governance practices affect differently the three sites.

The Trancão river basin, covering an area of 279 km^2, is a small basin heavily industrialized and densely populated. Its downstream urban area is prone to flash floods due to land use changes and high population density.

Risk addressed problems: Reduction in water availability and quality degradation, associated with more frequent and intense droughts, are the main concerns of agriculture and public water supply (EPAL) sectors. The main *agriculture adaptation* objectives in BINGO is to strengthen the economic agriculture sector by developing strategies for climate change adaptation in the region under low precipitation events and to identify the risk associated with salty inundation due to spring tides combined

with storms surges and sea level rise scenarios. *Public water supply (EPAL)* addresses essentially water resources competition, and how its governance affects the accomplishment of its objectives of raw water production. Water resources governance is a crossing issue between both sectors. *Flash flood hazard* to people safety and property in Trancão urban areas is also analysed.

Bergen, Norway

Bergen is enclosed between high mountains and the open sea. Situated on the west coast, Bergen is Norway's second largest city, with a population of about **270.000** inhabitants. Two study cases have been selected:

i) The **Damsgård area**, with a catchment of around **8.3 km²,** has an **urban drainage** system facing problems during intense precipitation events, that are becoming more frequent due to climate change. Stormwater discharge, combined sewerage overflow (CSO) and consequent pollution to receiving waters (the Puddefjord) are of the highest concern in the city of Bergen.

(ii) to identify the risk of water availability under drought conditions for **public water supply to Bergen**. Water sources provide from a set of reservoirs, namely, Jordalsvannet (**9.7** km^2), Svartediket (**12.3** km^2), Sædalen (**1.9** km^2) and Espeland (**9** km^2), all located in **small watersheds**.

Risk addressed problems: Due to previous periods of water shortage there is a concern about the capacity of **supplying Bergen with drinking water** during droughts. The existing risk will be estimated.

Being exposed to heavy precipitation loads, flash floods and storm water related challenges and the subsequent impacts on the wastewater and stormwater systems and recipients, the **urban drainage** system impacting the Damsgård area will be the focus of attention.

Badalona, Spain

Badalona with more than **215.000 inhabitants** within its administrative limits on a land area of more than **21.2 km^2**, is situated on the left bank of the Besòs River facing the Mediterranean Sea. Seven natural ephemeral watercourses**,** coming from the upper part of city (from the mountain to the sea) have been channelled below the urbanized area. The most valued resource and one of the main sources of income in Badalona is

tourism, based on their beaches, which stretch along nearly 5 km, with an average width of approximately 55 m and about 187.000 m^2 of sand. This space is occupied by 1.3 millions of visitors per year. **Urban drainage** in Badalona has a special relevance due to the climate and morphological characteristics of its catchments. Badalona´s drainage network is mainly a combined system with 318 km of sewers.

Risk addressed problems: The high demographic density and land imperviousness exacerbate urban flood risk and CSO affects negatively river and coastal water quality during intensive rainy events.

9.2.2 *Summary of natural hazards and impacted activities or sectors addressed in BINGO*

Natural hazards addressed

The **meteorological/ hydrological natural hazards** covered by the six research sites are:

- Extreme low precipitation / drought events;
- Extreme intense precipitation / flood events and;
- Spring tides, storm surges and sea level rise.

Water systems impacted

The water systems addressed as sources for several waters uses (public supply, irrigation, hydropower, leisure, etc.) or as receiving waters cover all categories of water, with several dimensions (Table 9.1). Artificial, urban drainage systems (wastewater and stormwater) are considered and analysed in 2 sites: Bergen and Badalona.

Some hydrographic basins are small with more natural and agricultural use of the land, as is the case of Peristerona, in Troodos. Some are medium basins, like the Wupper, with a strongly industrialized catchment. One is the largest basin in Europe, the international Tagus basin, where agricultural activity is strongly widespread. Some sites cover urban areas, like Bergen and Badalona, one covers a natural park (he Veluwe). A rich diversity is represented in BINGO research sites.

Table 9.1: Types of water bodies addressed

Water bodies		Water SOURCES				RECEIVING waters	
		Superficial inland			Groundwater	Fiord	Coastal
		Rivers	Reservoirs	Estuary			
DE	Wupper basin		●				
NL	Veluwe				●		
CY	Peristerona watershed	●			●		
	Pedieos watershed	●					
PT	C. Bode (Zêzere river)		●				
	Lower Tagus	●					
	Ota-Alenquer;				●		
	Tejo-Sado & Aluviões				●		
	Sorraia basin (2)		●				
	Trancão basin	●					
	Tagus estuary			●			
NO	Reservoirs (5)		●				
	Puddefjord fiord (Damsgård area)					■	
SP	Mediterranean Sea (Badalona)						■

Legend:

● very large; ● large; ● medium; ● small

Anthropogenic activities / sector analysed

WP4 is responsible within BINGO for assessing the impacts of extreme meteorological/ hydrological events on socio-economic water related activities at the six RS. The **activities/ sectors** addressed in BINGO are:

- Water resources management (DE and NL);
- Urban drainage management (NO and SP);
- Public water supply and (PT, CY, NL and NO);
- Agriculture (PT and CY).

Table 9.2 summarizes the activities/ sectors addressed according to type of hazardous events considered.

Table 9.2: Natural hazards and activities/ sectors addressed in BINGO

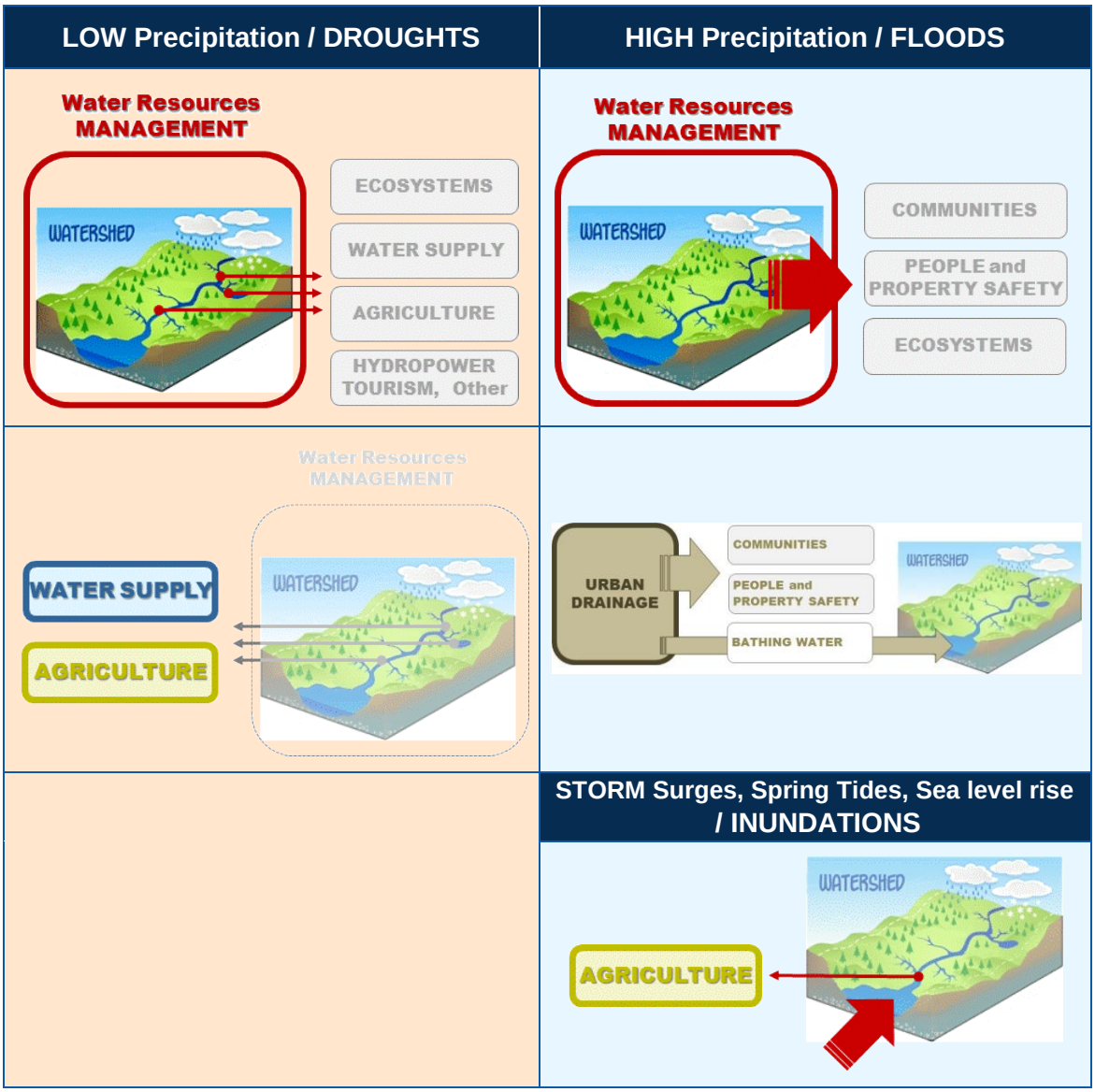

Table 9.3 summarises the activities/ sectors addressed in each research site per type of natural hazardous event, as well as the water related issues concerning the activities/ sectors analysed. Table 9.4 summarises the same information but structured by activity/ sector under analysis. In these tables, the entities responsible for the risk assessment development (risk owners) are already identified. The extent of risk assessment to be performed (risk identification or full risk assessment) is also indicated. Case studies performing solely flood hazard estimation do not have risk owners identified.

Table 9.3: Activities/ sectors addressed in each BINGO research site

	HYDROLOGIC Hazard		SECTOR / ACTIVITY	GEOGRAPHICAL AREA	Water related ISSUE	RISK OWNER	Risk Assessment extent	Risk Treatment
DE	●		**WATER RESOURCES MANAGEMENT**	Wupper river basin	**Water Availability**	**Wupper Association**	Risk assessment	YES
		●			**Inundations**			
NL	●		**WATER RESOURCES MANAGEMENT**	The Veluwe	**Water Availability**	**Provincial Government**	Risk assessment	YES
	●		**PUBLIC WATER SUPPLY**	The Veluwe	**Water Availability**	**Public Water Supply utility:** Vitens	Risk assessment	YES
PT	●		**AGRICULTURE**	Tagus: Sorraia Valley (VS)	**Irrigation Water Availability**	**Irrigators Association:** ARBVS	Risk assessment	YES
	●			Tagus: Lezíria Grande Vila Franca de Xira (LGVFX)	**Irrigation Water Availability & Quality (Salinity)**	**Irrigators Association:** ABLGVFX	Risk assessment	Water resources governance
		●			**Agricultural lands inundations**		Risk assessment	no
	●			Tagus: Lezíria do Vale do Tejo (LVT)	**Water resources governance**	**Farmers**	Risk identification	Water resources governance
	●		**PUBLIC WATER SUPPLY**	Superf. water intakes: C. Bode (Zêzere); Valada (Tagus) Groundwater intakes: Ota-Alenquer; Tejo-Sado; Aluviões	**Water Availability & Quality**	**Public Water Supply utility:** EPAL	Risk assessment	YES
		●	**People and property safety**	Trancão river basin (Tagus affluent)	**Urban Inundations**	-	Flood hazard identification	General List of adaptation measures
CY	●		**AGRICULTURE**	Peristerona Watershed	**Irrigation Water Availability**	**Irrigation Associations** of Downstream Peristerona Watershed	Risk assessment	YES
	●		**PUBLIC WATER SUPPLY**	Peristerona Watershed	**Water Availability**	**Community Council**s of Downstream Peristerona Watershed	Risk assessment	YES
		●	**People and property safety**	Pedieos Watershed	**Urban inundations**	-	Flood hazard identification	General List of adaptation measures
NO		●	**URBAN DRAINAGE MANAGEMENT**	Damsgaard Area	**Urban inundations**	Bergen **Municipality**	Risk assessment	YES
	●		**PUBLIC WATER SUPPLY**	Reservoirs intakes: Svartediket, Jordalsvatnet, Espeland, Saedalen, Kismul	**Water Availability**	Bergen **Municipality**	Risk identification	General List of adaptation measures
SP		●	**URBAN DRAINAGE MANAGEMENT**	Municipality of Badalona	**Urban inundations**	**Municipality** of Badalona	Risk assessment	YES
					Sea water quality			

Legend:

●	**- Droughts**
●	**- Innundations**

Table 9.4: Activities/ sectors addressed in each research site

HYDROLOGIC Hazard		SECTOR / ACTIVITY adressed			GEOGRAPHICAL AREA	Water related ISSUE	RISK OWNER	Risk Assessment extent	Risk Treatment
LOW Precipitation / DROUGHTS	●	DE	WATER RESOURCES MANAGEMENT		Wupper river basin	**Water Availability**	**Wupper Association**	Assessment	YES
	●	NL	WATER RESOURCES MANAGEMENT		The Veluwe	**Water Availability**	**Provincial Government**	Assessment	YES
	●	PT		AGRICULTURE	Tagus: Sorraia Valley (VS)	**Water Availability**	**Irrigators Association** ARBVS	Assessment	YES
					Tagus: Lezíria Grande Vila Franca de Xira (LGVFX)	**Irrigation Water Availability & Quality**	**Irrigators Association** ABLGVFX	Assessment	Water resources governance
					Tagus: Lezíria do Vale do Tejo (LVT)	**Water resurces governance**	**Farmers** LVT	Identification	Water resources governance
	●	CY		AGRICULTURE	Peristerona Watershed	**Irrigation Water Availability**	**Irrigation Associations** of Downstream Peristerona Watershed	Assessment	YES
	●	PT		PUBLIC WATER SUPPLY	Tagus	**Water Availability & Quality**	**Public Water Supply company:** EPAL	Assessment	YES
	●	CY		PUBLIC WATER SUPPLY	Peristerona Watershed	**Water Availability**	**Community Councils** of Downstream Peristerona Watershed	Assessment	YES
	●	NL		PUBLIC WATER SUPPLY	The Veluwe	**Water Availability**	**Public Water Supply company**: Vitens	Assessment	YES
	●	NO		PUBLIC WATER SUPPLY	Reservoirs intakes to Bergen	**Water Availability**	**Bergen Municipality**	Identification	General List of adaptation measures
HIGH Precipitation / FLOODS	●	DE	WATER RESOURCES MANAGEMENT		Wupper river basin	**Inundations**	Wupper **Association**	Assessment	YES
	●	NO	URBAN DRAINAGE MANAGEMENT		Damsgaard Area	**Urban inundations**	**Bergen Municipality**	Assessment	YES
	●	SP	URBAN DRAINAGE MANAGEMENT		Badalona	**Urban inundations Sea water quality**	**Municipality** of Badalona	Assessment	YES
	●	PT		People and property safety	Trancão	**Urban Inundations**	-	Flood hazard identification	General List of adaptation measures
	●	CY		People and property safety	Pedieos Watershed	**Urban Inundations**	-	Flood hazard identification	General List of adaptation measures
STORM S. SEA Rise	●	PT		AGRICULTURE	Tagus: Lezíria Grande Vila Franca de Xira (LGVFX)	**Agricultural lands Inundations**	**Irrigators Association:** ABLGVFX	Assessment	no

Legend: ● - Droughts ● - Innundations

Comparison of water resources management and water related sectoral activities addressed in BINGO research sites

Water resources management

Two northern Europe research sites, with similar climatic characteristics, address water resources management under extreme climate events as the adaptation key issue in BINGO: the Veluwe region, in Netherlands, and the Wupper basin, in Germany.

The **Veluwe** case addresses the management of groundwater and is concerned with the optimizations of resources management under low precipitation events. It is intended to understand up to what extent the main water user (a public water supply entity - Vitens) can be supplied by the groundwater system while complying with environmental requirements and assuring economic actives dependent on environmental landscape.

The **Wupper** case addresses the management of surface water, heavily artificialized by systems of several reservoirs, and is concerned with the optimizations of water resources management under low precipitation events as well as with intense precipitation events. In the first case multiple water users' customers concerns and environmental status compliance are addressed and in the latter people safety and goods and properties are the major concerns.

Along with the climate variability, the water resources governance policies and practices affect the sectoral activities dependent on water resources. Several of the BINGO research sites address climate changes adaptation of the public water supply and agriculture sectors. The sectoral decisions upon adaptation strategies are often dependent on regional water resources management under climate change circumstances and on European policies, increasing the existing level of uncertainty.

Public water supply

Three BINGO sites, located in different climatic areas, address the adaptation of the public water supply sector in what concerns production of drinking water: **EPAL**, in Tagus (Portugal), **Vitens**, in the Veluwe (Netherlands) and the **Communities of Peristerona** (Cyprus). **Bergen** will only perform risk identification concerning water intakes, but no adaptation.

EPAL main water sources are superficial, with groundwater representing mostly strategic reserves. Vitens and the Communities of Peristerona have mainly groundwater sources. EPAL and Vitens are very large utilities supplying more than 2 million people. On the other hand, the Communities of Peristerona are small, struggling with technical and financial difficulties

Agriculture

Agriculture adaptation, regarding water availability and quality for irrigation, is addressed in **Tagus / Sorraia** basins (Portugal) and in **Peristerona Watershed** (Cyprus). Water sources are superficial in Sorraia and Peristerona. In the remaining Tagus basin groundwater are also significant sources. Once again, relevant differences exist between the two research sites. Agriculture in the lower Tagus, is maybe the most developed agriculture in Portugal, often using state of the art technologies and practices, and farms having scale size potential. On the other hand, the agriculture sector selected as research site in Cyprus is of small dimension with farmers with low level of education.

Urban drainage management

One northern Europe city (**Bergen**) and one southern one (**Badalona**), with similar population dimension, address urban drainage management under intensive precipitation events. Drainage systems are totally piped, thus being completely artificial systems.

In both cases they are combined systems, draining stormwaters and sewerage, therefore, both cause with similar impacts: storm water discharges flooding the respective urban areas and CSO with causing pollution impact on receiving waters, affecting aquatic leisure activities and tourism. Bergen CSO impacts a fiord while Badalona impacts Mediterranean beaches.

9.3. Objectives, Scopes and specific objectives

The general objectives of the risk assessment processes, the scopes of analysis and their specific objectives are summarised in Table 9.5, Table 9.6, Table 9.7 and Table 9.8 per type of activity, respectively water resources management, public water supply, agriculture and urban drainage management.

Objectives are related with the mission of entities developing the risk assessment and adaptation strategies or envisage general strengthening of the key economic sectors.

The focuses of analyses (scopes) cover:

- Continuity of services (droughts);
- Preserve integrity of irrigation infrastructures (droughts);
- Analyse water resources governance on agriculture (droughts and floods);
- Economic and financial (droughts and floods);
- Reputation and/ or image sectors (droughts and floods);
- Protection of the environment (drought and floods);
- People and property safety (floods);

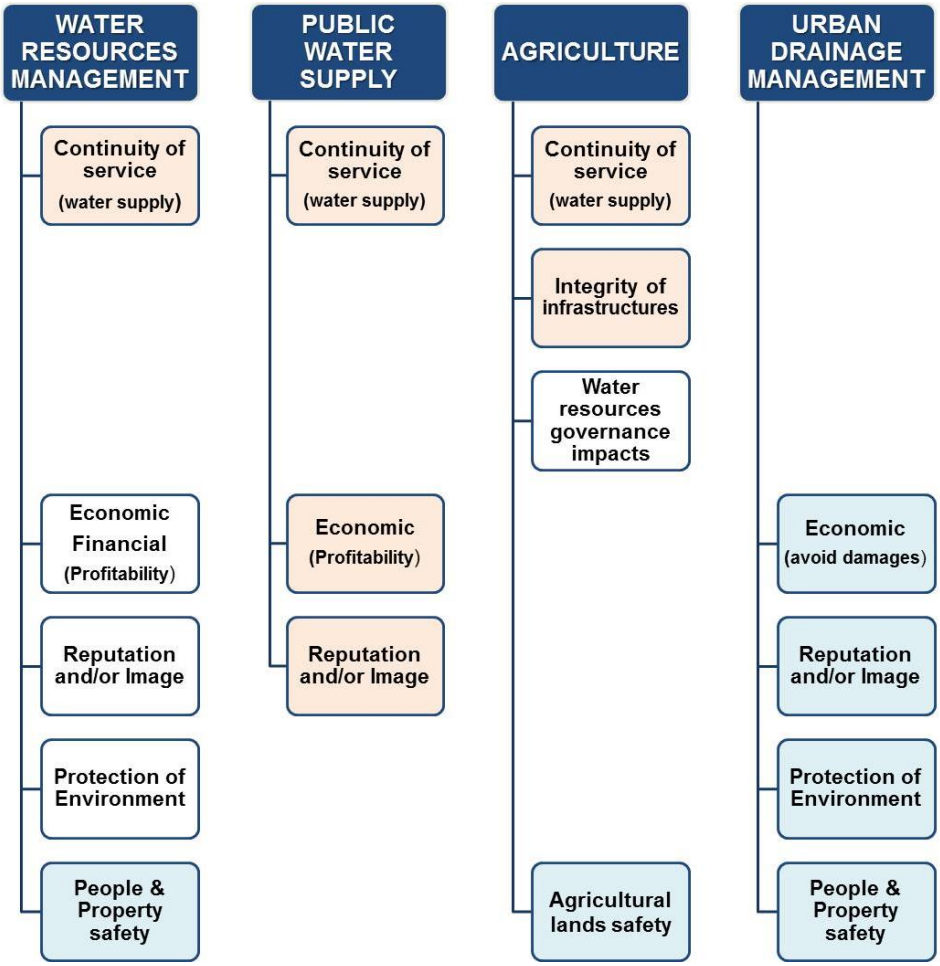

Figure 9.1: Scopes of BINGO risk assessment processes

Table 9.5: Objectives, scope and specific objectives - WATER RESOURCES MANAGEMENT

HYDROL. HAZARD		ACTIVITY/ SECTOR	RISK OWNER	PROBLEM FORMULATION within BINGO: OBJECTIVES	SCOPES	SPECIFIC OBJECTIVES	SIGNIFICANCE OF RISK: RISK CRITERIA – Function of:	R. Assessment extent: Identif.	Analysis	Evaluat	Risk Treatment: SITE specific	GOVERNANCE suggestions of Improvement
LOW Precipitation / DROUGHTS	NL	Groundwater WATER RESOURCES MANAGEMENT	PROVINCIAL GOVERNEMENT	**Sustainable groundwater MANAGEMENT** *under different climate scenario's and seasons*	**Provide water resources** for public water supply (PWS)	Optimize the sustainable **level of allowances**	**Volume:** Demand of PWS exceeds current level of allowances (Volume demanded - volume allowed > 0)	✓	✓	✓	YES	Water resources governance
					Protect and inprove the natural, landscape and cultural heritage qualities of the Veluwe through sustainable groundwater management	Minimize economic impact on regional tourism	**Euros:** negative economic impact on tourism					
						Meet **Natura 2000 objectives**	Reduction in **number** of protected **habitat**s, and plant and animal **species**					
					Provide sufficient volumes of groundwater for the **maintainance of surface waters** (waterstreams)	Ensure **ecological flow** in water streams	**Nº streams** (32 total; 4 N2000) with flow **< ecological flow;** **Nº of key species** in stream					
	DE	River basin WATER RESOURCES MANAGEMENT	WUPPER ASSOCIATION	**PROVISION OF ENOUGH WATER, during low precipitation events, for:** **- members/customers according to contracts (water supply, industry); - own hydropower generation; - environment (ecological flow)**	**Service continuity** of water provision for members/customers according to contracts: - drinking water treatment utilities - industries	Assure sufficient **volumes** of water supply during 365 days/year for drinking water treatment and all industrial costumers	- **Nº Days** without sufficient raw water supply for drinking water treatment; - **Nº Days** without sufficient water for industrial use; - **Volumes:** Missing amounts of raw water per day; - **Nº of Unsupplied customers** (Customers minutes loss); - **Nº** of Un-/undersupplied industrial companies.	✓	✓	✓	YES	Water resources governance
					Profitability - Financial (WA)	Maximize **flow for hydropower** generation	**Euros** - Financial losses due to unprovided hydropower supply					
						Maintanance of **earnings**	**Euros** -Financial losses of WA due to unprovided raw water					
							Euros - Financial losses on water supply entities or industrial companies caused by substitution of missing raw water					
					Protection of **Environment**	Assure **ecological flow** in duration and quantity	- **Nº Days with flow** < ecological flow,					
							- **Volumes: Quantity of flow** < ecological flow					
					Maintenance of **good Reputation** and **Image**	Avoid bad media **critics or reviews**	**Nº of reports** in public media with critics or bad reputation					
HIGH Precipitation / FLOODS	DE	River basin WATER RESOURCES MANAGEMENT	WUPPER ASSOCIATION	**MANAGE WATER RESOURCES for protection of goods and property protection and safeguard of population** (Management of surface water level, protection against floods for different annualities (depending on catchment and possibilities) Keeping of legal requirements concerning treatment of waste/stormwater)	**Protection of environment**	Assure waste water treatment complience with legal requirements 365 days/year	- **Nº Days** without sufficient waste water treatment (effluent quality does not comply to legal requirements)	✓	✓	✓	YES	Water resources governance
					People and property safety	Protection of people life / safety	**PEOPLE SAFETY:** - **No.** of people **died or injured/flood**;					
						Protection of: - public infrastructure (e.g. roads), - own assets (e.g. Wasetwater treatment and hydropower plants), - assets of members (e.g. drinking water treatment and industrial plants) and - private property (e.g. houses)	**PROPERTY SAFETY**: - **No.** of infrastructure, plants, houses destroyed/flood - **Area** of flooded fields/flood; - **No**. of floodings per year;					
					Reputation and image	Avoid bad media critics or reviews	**No. of reports** in public media with critics or bad reputation;					
					Economic (External to WA)	Avoid financial losses external to WA	**Euros** - Costs for reparation of damages **Euros** - Costs for loss of production					
					Financial (WA)	Avoid WA financial losses	**Euros** - Penalty fees. **Euros** - Costs for reparation of damages					

Table 9.6: Objectives, scope and specific objectives – PUBLIC WATER SUPPLY

				PROBLEM FORMULATION within BINGO			SIGNIFICANCE OF RISK	R. Assessment extent			Risk Treatment	
HYDROL. HAZARD		ACTIVITY/ SECTOR	RISK OWNER	OBJECTIVES	SCOPES	SPECIFIC OBJECTIVES	RISK CRITERIA Function of:	Identif.	Analysis	Evaluat	SITE specific	GOVERNANCE suggestions of Improvement
LOW Precipitation / DROUGHTS	CY	PUBLIC WATER SUPPLY	COMMUNITY COUNCILS of Downstream Paristerona	**Supply drinking water to community households**	**Continuity of water supply**	To supply water in adequate **quantity** and at affordable **cost**	**Groundwater yield** (m3/hour) and **volume consumed** (e.g. l/cap/day)	✓	✓	✓	YES	Water resources governance
						To supply water with adequate **quality** (i.e., that it will not harm customers' health)	EU drinking water **quality standards**					
	PT	PUBLIC WATER SUPPLY	*Public Water Supply utility:* EPAL	**Assure efficient production of drinking water** ***in climate change scenarios***	**Continuity of water production (related to water intakes):** Fulfil needs and expectations of customers	To supply water with adequate **quality** (i.e., that it will not harm customers' health)	**Daily Average Flow %** (Volume supplied)/ (Volume requested) and **Duration** (month)	✓	✓	✓	YES	Water resources governance
						To supply water in adequate **quantity** (i.e., meeting every customer's needs)	**Daily Average Flow %** (Volume supplied) / (Volume requested) and **Duration** (month)					
						To supply water with adequate **reliability** (i.e., ensuring the continuity of the supply).	**Number of clients** affected by the lack of water supply and/or duration of the service failure					
					Profitability: Ensure adequate profitability	To achieve the **economic and financial** strategic objectives	**Euros** of Loss of profits due to Opex increase					
					Image	To ensure the **trust** from the **customers** as well as the **reputation** among other national or international **water utilities**	**Nº, type and subject** of **Negative news** in the media per year					
	NL	PUBLIC WATER SUPPLY	*Public Water Supply utility* VITENS	**Assure efficient production of drinking water** ***in climate change scenarios***	**Service continuity**: Water provision for public water supply and for other consumers (industry)	Assure sufficient **volumes** of water supply during 365 days/year for drinking water and all industrial costumers	**Number of minute**s in daily average flow with no supply	✓	✓	✓	YES	Water resources governance
					Reputation of Vitens	Keep and improve positive **image** of sustainable and environmental friendly company	**No. of reports** in public media with critics or bad reputation					
	NO	PUBLIC WATER SUPPLY	BERGEN Municipality	**Assure sufficient raw water provision for drinking water supply** ***in climate change scenarios***	**Service continuity:** Water provision for public water supply	To supply water in adequate **quantity**: meeting customers' need without compromising requirements to storage reserves	-	✓			General list of adaptation measures	Water resources governance

Table 9.7: Objectives, scope and specific objectives – AGRICULTURE

HYDROL. HAZARD		ACTIVITY/ SECTOR	RISK OWNER	PROBLEM FORMULATION within BINGO: OBJECTIVES	PROBLEM FORMULATION within BINGO: SCOPES	PROBLEM FORMULATION within BINGO: SPECIFIC OBJECTIVES	SIGNIFICANCE OF RISK: RISK CRITERIA Function of:	R. Assessment extent: Identif.	R. Assessment extent: Analysis	R. Assessment extent: Evaluat	Risk Treatment: SITE specific	Risk Treatment: GOVERNANCE suggestions of Improvement
LOW Precipitation / DROUGHTS	CY	AGRICULTURE	IRRIGATON ASSOCIATIONS of Peristerona	**Ensure fair, efficient and sustainable management of irrigation water supply**	Ensure **sufficient irrigation water** for irrigated agriculture	Match **demand** with sustainable supply	**Volume: %** (Volume supplied)/ (Volume requested)	✓	✓	✓	YES	Water resources & Agricultural sector (water related issues)
					Maintenance of infrastructure (pumps, pipes, concrete channels)	Reduce **water losses**	**Volume: %** (Water supplied / water abstracted)					
	PT	AGRICULTURE	IRRIGATORS ASSOCIATIONS: ARBVS	**Efficient management, conservation and exploitation of the Public Irrigation Infrastructures** of the Sorraia Valley	**Assure supply of water demand during agricultural campaigns under extreme weather conditions (droughts)** (Fulfil needs and expectations of associated and beneficiary farmers)	Supply water **demanded**	**Volume:** % (Volume supplied)/ (Volume demanded)	✓	✓	✓	YES	Water resources & Agricultural sector (water related issues)
						Supply water **in due timing**	**Timing:** Nº of day in delay (water delivery date – requested date)					
					Preserve the integrity and operability of infrastructures (Fulfil DGADR contractual expectations)	Achieve low levels **of water losses**	**% waters losses** (Water supplied / water abstracted)					
			IRRIGATORS ASSOCIATIONS: ABLGVFX	**Efficient management, conservation and exploitation of the Public Irrigation Infrastructures** of LGVFX	**Assure supply of water demand and quality during agricultural campaigns under extreme weather conditions (droughts)** (Fulfil needs and expectations of associated and beneficiary farmers)	Supply water **demanded**	**Volume:** % (Volume supplied)/ (Volume demanded)	✓	✓	✓	no	
						Supply water with **quality**	**Salinity**					
					Preserve the integrity and operability of infrastructures (Fulfil DGADR contractual expectations)	Achieve low levels **of water losses**	**% Waters losses** (Water supplied / water abstracted)					
			FARMERS of Lezíria do Vale do Tejo	**Strengthen the agriculture economic sector** in Lezíria do Vale do Tejo	**Analyse water resources governance impacts in agriculture in Lezíria do Vale do Tejo**	**Identify the water resources governance policies and practices that may affect irrigation** during agricultural campaigns under extreme weather conditions (droughts)	-	✓			no	
STORM S. SEA Rise	PT	AGRICULTURE	IRRIGATORS ASSOCIATIONS : ABLGVFX	**Assure efficient management and operation of dykes** ***during extreme weather conditions (inundations)***	**Assure the protection of agricultural land** (Fulfil needs and expectations of beneficiary farmers)	**Avoid inundation** of agricultural lands and preserve the integrity and operability of the protection and water supply infraestructures	**Volume** of water that overtops dikes	✓	✓	✓	no	no

Table 9.8: Objectives, scope and specific objectives – URBAN DRAINAGE

				PROBLEM FORMULATION within BINGO			SIGNIFICANCE OF RISK	R. Assessment extent			Risk Treatment	
HYDROL. HAZARD		ACTIVITY/ SECTOR	RISK OWNER	OBJECTIVES	SCOPE	SPECIFIC OBJECTIVES	RISK CRITERIA Function of:	Identif.	Analysis	Evaluat	SITE specific	GOVERNANCE suggestions of Improvement
HIGH Precipitation / FLOODS	NO	URBAN DRAINAGE SECTOR	BERGEN Municipality	Preparation of urban drainage systems to **avoid CSO** **during extreme precipitation conditions**	**Economic** (Protection of Economic activites)	**Protection of critical public infrastructure** (e.g. main roads and railways, hospitals, parts of supply systems for energy, drinking water, sanitation systems)	No. of items critical infrastructure flooded Costs for reparation of damages (Euros)	✓	✓	✓	YES	
						Reduction of economic **damages on private goods and properties**	Costs for reparation of damages (Euros) (e.g. reimbursements made by insurance companies)					
						Avoid impact on **aquatic leisure activities**	EU standard for bathing					
						Avoid impact on **recreational activities at banksides**	Area of flooded fields					
						Avoid loss of production	Nr. of days/hrs production downtime caused by flooding					
					Protection of environment	**Avoid pollution** from flooded **industrial** sites (industrial sites esp. with dangerous materials)	EU standard					
					Reputation and image	Avoid **Loss of trust** in the municipality	Customer satisfaction Nr. of negative reports in media pr. Year					
	ES	URBAN DRAINAGE SECTOR	BADALONA Municipality	Preparation of urban drainage systems to **reduce flash floods** ***during extreme precipitation events***	**People safety**	To minimize **flood risk for people and vehicles** during heavy storm events	**% of area** classified as moderate or high hazard according the vulnerability criteria defined.	✓	✓	✓	YES	
					Economic (Protection of goods, properties and economic activities)	Reduction of **direct and indirects** economic **damage** on goods and properties	**Expected Annual Damage (EAD)** Flood damages for 10 years of return period with CC					
				Preparation of urban drainage systems to **reduce CSOs** ***during moderate and extreme precipitation events***	**People safety**	To minimize risk for **people** due to the **contamination** of bathing waters during and after moderate and heavy storm events	**% of km** of beach whose bathing water presents high bacterial contamination according to EU bathing water Directive thresholds	✓	✓	✓	YES	
					Reputation and image	**Avoid Loss of trust** in the municipality	**Number of days** of non compilance of the EU bathing water directive (bathing forbidden and beaches closed) in a representative year or bathing season					
					Economic (Protection of goods, properties and economic activities)	Reduction of economic impacts on **tourism, fishing and leisure** sectors due to CSOs	**Tangible indirect damages (expressed in Euros)**					

9.4. Key stakeholders

According to stakeholder definition (Annex I), stakeholder is a person or organization that can affect, be affected by, or perceive themselves to be affected by a decision or activity. A decision maker can be a stakeholder.

Several types of stakeholders need to be taken in account when performing risk assessment (WP4) and risk adaptation (WP5), either because they condition the external context, as is the case of European Union policies (e.g. environmental protection or agricultural policies) or national policies, or because they directly affect activities being performed or are impacted by them. In fact, European Union acts more as policy maker than a decision maker but it strongly influence the external context.

Figure 9.2 summarizes the main types of stakeholders relevant to BINGO research sites risk management processes. Under low precipitation events clients, or customers, are considered to be the stakeholders more directly relevant to the activities being accessed (water resources management, public water supply and agriculture). In case of inundations events, people and entities affected are the most relevant. Clients and persons or entities affected will be the main stakeholders to take in account to establish the risk criteria and tolerance levels.

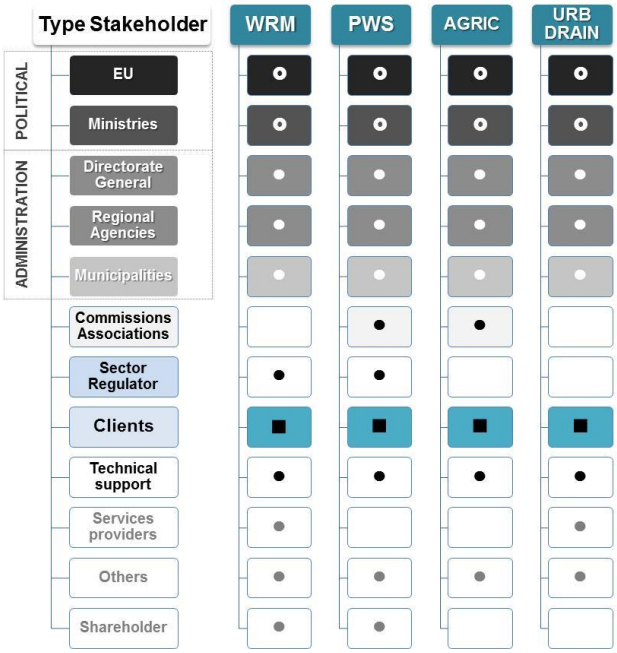

Figure 9.2: Types of stakeholders relevant to BINGO sites.

Table 9.9 and Table 9.10 identify the relevant stakeholders for each research site, indicating if they are BINGO partners, if they are integrated in the BINGO Community of Practice (CoP) or if they are not involved at all.

9.5. External and internal contexts: Similarities and singularities

Natural climatic and geographical characteristics

The six research sites are located in different climatic regions (Figure 9.3), with different mean annual temperatures and mean annual precipitations (Figure 9.4).

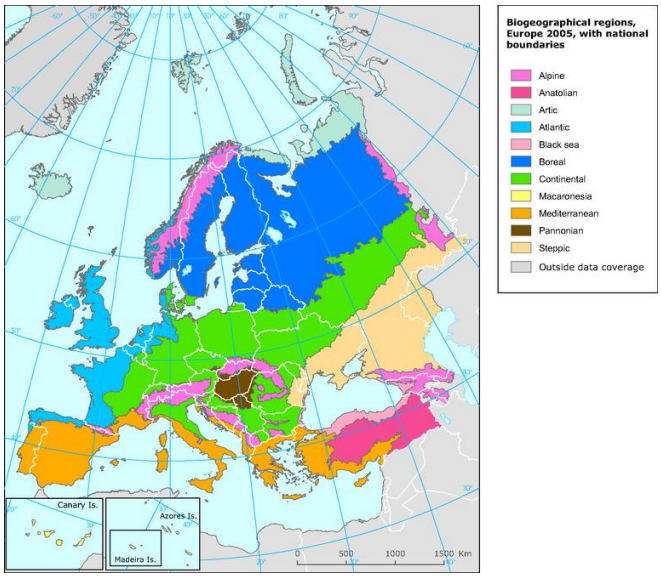

Figure 9.3: Europe biogeographical regions. Source: http://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-europe-2005-with-national-boundaries

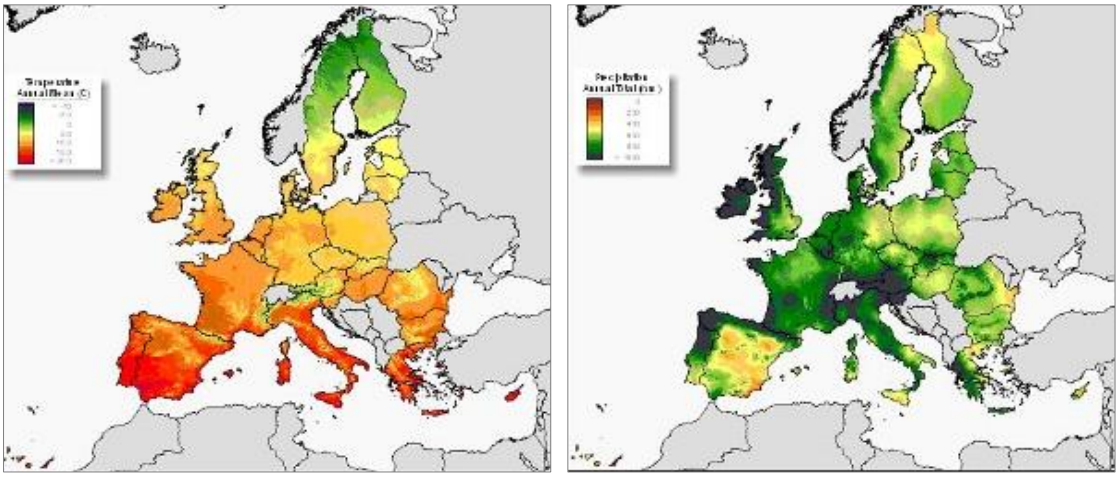

Figure 9.4: Europe mean annual temperature and mean annual precipitation Source: http://esdac.jrc.ec.europa.eu/content/european-food-safety-authority-efsa-data-persam-software-tool

Northern and Southern European countries are usually associated with different CC driven problems and with different climatic and socio-economic conditions. The Northern countries are traditionally understood to deal with problems related to excess of rain, such as floods, whereas the Southern regions generally have the emphasis on water shortage and its impacts on land use, ecosystems and water resources.

Table 9.9: Stakeholders identified for water resources management and public water supply activities

Legend:

- ● - Droughts
- ● - Innundations

BINGO Status:

1 - BINGO partner
2 - CoP
3 - None

	STAKEHOLDER	● DE	● DE	● NL	● NL	● PT	● CY
	STAKEHOLDER	WRM (Wupper Association)		WRM (Provincial Government)	PWS (Vitens)	PWS (EPAL)	PWS (Community Councils)
POLITICAL EU	EU	European Parliament and Council		European Parliament and Council	European Parliament and Council		
	EU	DG-Environment		DG-Environment		DG-Environment	DG-Environment
	EU						DG-Regional Policy
	EU				European Investment Bank (EIB)		
POLITICAL MINISTRIES	ADMIN / Ministry of Agriculture						Ministry of Agriculture, Rural Development and Environment
	ADMIN / Ministry of Environment	Ministry for Climate Protection, Environment, Agriculture, Conservation and Consumer Protection of the State of North Rhine-Westphalia (MKULNV - Ministerium für Klimaschutz, Umwelt,		Ministry of Infrastructure and the Environment	Ministry of Infrastructure and the Environment	Ministry of Environment, Regional Planning and Regional Development (MAOTDR - Ministério do Ambiente, do Ordenamento do Território e do	
	ADMIN / Ministry of Economie			Ministry of Economic Affairs	Ministry of Economic Affairs		
CENTRA L & REGIONAL AGENCIES (ADMINISTRATION)	ADMIN / Directorate General Water & Envrinoment Authority	District Governments (i.e. Bezirksregierung Düsseldorf, Bezirksregierung Köln)		Directorate of Space and Water (Ministry of Infrastructure and the Environment); Directorate of Rijkswaterstaat (Ministry of Infrastructure and the Environment)	Human Environment and Transport Inspectorate (ILT) (of the Ministry of Infrastructure and the Environment)	APA - Portuguese Environment Agency (Agência Portuguesa do Ambiente)	Water Development Department & Geological Survey Department (Ministry of Agriculture, Rural Development and Environment)
	ADMIN / BASIN or REGIONAL level Water & Envrinoment Authority	Environmental Agencies (e.g. Wuppertal, Solingen, Remscheid, Leverkusen, Oberbergischer Kreis)		- Waterboard Vallei & Veluwe - Local municipal planning departments	- Province of Gelderland - Waterboard Vallei & Veluwe - Local municipal planning	ARH Tejo - Tagus River Basin District Administration - APA regional services	
	ADMIN / Directorate General of Agriculture						
REGULATORS	Sector Regulator			- Rijkswaterstaat (regulatory agency of the Ministry of Infrastructure and the Environment that manages primary (water) infrastructure in the Neterlands) - Staatsbosbeheer (regulatory agency of the Ministry of Economic Affairs responsible for nature and forestry management)		ERSAR	
COMI SSIO	Management Commissions					Reservoirs Management Commission	
CLIENTS	Other Country sharing the river Basin						
	Costumers	Members of Wupperverband: - Public water supply entities (i. e. Wasserversorgungsverband Rhein-Wupper, WSW Energie & Wasser AG);	Members/customers of Wupperverband with assests in flooding areas	- Vitens (public water supply) - Nature-based tourism - Farmers - Industries - Natuurmonumenten (nature conservation organization) - Other land users and owners	- Households - Farmers - Industries	Bulk Water: Municipalities Distribution: Domestic; Commerce & Industry; State; Fire departments; ...	Rural households
OTHERS	Tecnhical support / Information	LANUV - State Office for Conservation, Environment and Consumer Protection North Rhine-Westphalia		- KWR Watercycle Research Institute - Hogeschool van Hall Larenstein - Arcadis	- KWR Watercycle Research Institute - Hogeschool van Hall Larenstein		Water Development Department Geological Survey Department
	Weather Forecast						
	Services providers			- Rijkswaterstaat (infrastructure provider) - Staatsbosbeheer (nature management)		Maintenace and operational out-services	
	Others	Environmental NGOs; Farmers; Public		- Stichting Natuur & Milieu (nature NGO) - Gelders Particulier grondbezit (association of local land owners) - Bekenstichting (nature NGO) - Bosgroep (association of land owners) - Milieuzorg Noord-West Veluwe (nature NGO) - KNNV/NWE (nature NGO) - Platform Water Vallei & Eem (nature NGO) - Stichting Nauur- en Milieuzorg Noord-West Veluwe (nature NGO)		EDP - Eletricidade de Portugal (Eletricity of Portugal) Representatives of recreational uses of Castelo do Bode reservoir	
INT. STAKE.	Shareholder	Wupperverband				Grupo AdP - Águas de Portugal	

Table 9.10: Stakeholders identified for agriculture and urban drainage management activities

Legend:

- ● - Droughts
- ● - Innundations

BINGO Status:

- 1 - BINGO partner
- 2 - CoP
- 3 - None

		● PT AGRIC (Irrigators Associations)	● PT AGRIC (FARMERS)	● CY AGRIC (Irrigation	● NO URBAN DRAINAGE (Bergen City)	● ES URBAN DRAINAGE (Badalona
	STAKEHOLDER	**STAKEHOLDER**				
POLITICAL EU	**EU**					
	EU	**DG-Agriculture and Rural Development**		**DG-Agriculture and Rural Development**		**DG-Environment**
	EU					
POLITICAL MINISTRIES	**ADMIN / Ministry of Agriculture**	**MAFDR - Ministry of Agriculture, Forestry and Rural Development** (MAFDR - Ministério da Agricultura, Florestas e Desenvolvimento Rural)		**Ministry of Agriculture, Rural Development and Environment**		**Ministry of Agriculture and Fisheries, Livestock and Environnement** (Ministerio de Agricultura y Pesca, Alimentación y Medio Ambiente)
	ADMIN / Ministry of Environment	**MAOTDR - Ministry of Environment, Regional Planning and Regional Development** (MAOTDR - Ministério do Ambiente, do Ordenamento do Território e do			**Miljøvern departmentet** (Ministry of Environment)	
	ADMIN / Ministry of Economie					
CENTRA L & REGIONAL AGENCIES (ADMINISTRATION)	**ADMIN / Directorate General Water & Envrinoment Authority**	**APA - Portuguese Environment Agency** (Agência Portuguesa do Ambiente)		**Water Development Department** (Ministry of Agriculture, Rural Development and Environment)	**Directorate for energy and water resources (NVE)**	**Dirección General del Agua**
	ADMIN / BASIN or REGIONAL level Water & Envrinoment Authority	**ARH Tejo - Tagus River Basin District Administration - APA regional services** (Administração de Região Hidrográfica do Tejo)			**Regional County Authority** (Fylkesmanen)	**ACA - Catalan Water Agency**
	ADMIN / Directorate General of Agriculture	**DGADR -Directorate General for Agriculture and Rural Development**	**DRAP LVT - Regional Directorate for Agriculture and Fishery of Lisbon and Tagus River Valley** (DRAP LVT-Direção Regional de Agricultura e			
REGULATORS	**Sector Regulator**	-	-			
COMI SSIO	**Management Commissions**	**Reservoirs Management Commission**	-			
CLIENTS	**Other Country sharing the river Basin**	**SPAIN (Tagus basin)**				
	Costumers	**Associated and Beneficiary Farmers**		**Farmers**	**Inhabitants (Domestic), inductrial, public**	**Inhabitants (Domestic), industrial, public**
OTHERS	**Tecnhical support / Information**	**COTR - Operatve Center and of Irrigation Technology** (Centro Operativo e de Tecnologia de	**Farmers Associations**	**Water Development Department & Geological Survey Department**		**Aquatec**
	Weather Forecast	**IPMA - Weather Forecast Institute**	**IPMA - Weather Forecast Institute**			
	Services providers				**Maintenace and operational out-services**	**AMB - AB (Public-private company)**
	Others		**Intermunicipal Community of Lezíria do Tejo** (CIM LT Comunidade Intermunicipal da Lezíria do Tejo)			
INT. STAKE.	**Shareholder**				**Departments and agencies of the municipality in Bergen**	

In BINGO, the three Northern RS focus on problems usually associated with Southern Europe, such as water shortage and its impacts on water demand activities, with relevance to drinking water supply systems (in Bergen, for instance) or for nature management (in the Veluwe Park). On the other hand, the three BINGO Southern RS showed to be also concerned with intense precipitation and floods (Spain, Portugal and Cyprus).

External PESTLE context and internal context

Different political, socio-economic **external contexts** affect the adaptation capacities and strategies of the entities in charge as well as their internal context as dimension (size), people age, education level, or coping capacity.

Water resources governance is a cross-cutting issue among sites where water resources management is the primary activity addressed (NL and DE) and sites where sectoral adaptation (PWS or agriculture) depends not only of climate changes but also on water resources policies and practices. For public water supply it is, in fact, the most relevant dimension of the companies' external context. Water governance context will be deeply analysed in work package 5.

A similitude among the six research sites is the legal context. In fact, and not surprising, all RS pointed out the importance of European Directives and agreements that drive and influence policies regulating water uses. In fact, resources are limited and water uses are under pressure from urbanisation, agriculture and climate change factors. Therefore, in the European Union (EU), water related uses are of the responsibility of each member state, but union-wide policies have come into force. The most relevant water policies in the EU, in what concerns BINGO research sites, are the following Directives: Water Framework Directive (2000/60/EC); Bathing Water Directive (2006/7/EC) Nitrates Directive (91/676/EEC and later updates); Fertilizers (Regulation (EC) No. 2003/2003 of EP)**;** Pesticides (Directive 2009/128/ EC); Sewage sludge used in agriculture (Directive 86/278/CEE); Urban Wastewater Directive (91/271/EEC). It was amended by Directive 98/15/EC; Groundwater Directive (2006/118/EC), Floods Directive (2007/60/EC), Biodiversity (Nature 2000), Birds conservation (79/409/CEE) and Habitats (92/43/CEE). Those Directives define the responsibilities within water utilities regarding the effects of water production on human health and ecosystems, with EU Member States enacting national legislation to implement them.

The differences in the **internal contexts**, as dimension of the entities and even the education level of their personnel, put in evidence several governance dimensions that

need to be taken in account when setting strategies, as for example, the different access to funding programmes for technological improvement and therefore adaptation capacity.

When presenting activities addressed in BINGO research sites in section 9.2, some comparative aspects of the context were briefly referred, as dimension and others.

Being agriculture a particular case addressed in BINGO, the identification of the most relevant similarities and singularities of the external and internal contexts for the two research sites addressing this sector, Tagus basin (PT) and Peristerona watershed (CY) is presented in Table 9.11.

9.6. Conclusions and recommendations

The objective of this report was to establish the context for Risk Management Process in the six BINGO RS. Four main activities were identified: i) Water resources management (DE and NL); ii) Urban drainage management (NO and SP); iii) Public water supply and (PT, CY, NL and NO) and iv) Agriculture (PT and CY). The risk scope and objectives of these activities as well as their internal and external context, involving fully identification of risk owners and main stakeholders was fulfilled.

As a general conclusion, using the BINGO research sites as an example, it is known that the regions addressed are located in different geographical parts of Europe and involve sea-side, insular and continental case studies. Within this RMP step, it was acknowledged that the BINGO RMP will involve activities with diverse internal and external contexts as well as very different economic conditions. However, they have one thing in common: all of them are vulnerable to climate change and extreme weather phenomena and to conflicts of uses.

Following the RMP context establishment, two others steps will be carried out within WP4. They will be performed in Task 4.2 (Risk Identification) and Task 4.3 (Risk Analysis and Risk Evaluation). The latter will provide decision on the risks that need treatment, which is based on the comparison of results from risk analysis with previously set criteria (WP5). Recommendations to perform the following steps of the RMP in the six RS are presented in Annex II.

Table 9.11: Comparison of agriculture contexts

EXTERNAL CONTEXT – PESTLE approach			
PESTLE dimension	**RS KEY ISSUES**	**PT**	**CY**
POLITICAL	EU agricultural policies affecting water related issues	Common Agricultural Policy (CAP) provides incentives for the adoption of water saving technologies. The Code of Good Agricultural Practices promotes the rational use of irrigation water as well as application of fertilizers and phytopharma. Under Rural Development Plan (2014-2020) any farmer that will not comply with environmental policies and good agricultural practices is not be eligible for receiving subsidies. Although irrigation water is managed by farmers within the association, any important political decision regarding agriculture affects farming operations.	
		PT joined the EU on 1st of January 1986 Since then, under CAP policies many small farmers lost competitiveness and stopped activity. Big farmers gained competitiveness and took advantage of existing opportunities to improve.	CY joined the EU on 1st of May 2004 Prior to Cyprus' accession to the EU, the government was financially supporting irrigation association in establishing and maintaining the irrigation networks. These funds are not available any more, as it is seen as double funding (farmers are already subsidised through the Rural Development Programme).
	National agriculture policies regarding Water pricing policy	Full cost recovery under the Water Framework Directive is not yet implemented in the agriculture sector. The water pricing policy (WFD requirement) does NOT affect the demand of irrigation water	Full cost recovery under the Water Framework Directive is not yet implemented in the agriculture sector. The water pricing policy (WFD requirement) affects the demand of irrigation water (although full cost recovery is not yet implemented in the agriculture sector)
	Water resources governance	Water resources management practices affect water availability and quality for irrigation	
ECONOMIC	EU market policies; Regional economic development	Food security policies promote very highly demanding cultures as for example rice, through subsides, that makes these cultures very attractive to farmers. Local agro-food industries assure products flow	Agricultural land has decreased due to market pressures and people shift to non-farm activities.
SOCIAL	Farmers education and age Rural attractiveness / migration	High level of academic education of irrigator's association's technicians and of customer's farmers. Vicinity to Lisbon favours living in rural areas of lower Tagus. Agro-food industries favour employment in the region and influences type of crops demand.	Rural depopulation and migration to urban areas. Many irrigation associations terminated their operations due to the termination of financial support by the government and the insufficiency of funds to maintain the irrigation network, with strog social impact. Some irrigation associations, however, with better management approaches (e.g. timely collection of water bills and re-investment in the irrigation network) and have main their operation. Due to later EU adhesion CY is presently going through a process that PT already experienced some years ago.

EXTERNAL CONTEXT – PESTLE approach			
PESTLE dimension	**RS KEY ISSUES**	**PT**	**CY**
TECHNICAL	Recent opportunities and access to them	New technologies have been emerging that are useful to the agriculture sector (e.g. easy remote communication allows irrigation adjustment to real water needs, based in weather-soils monitoring; use of drones in cultures and equipment control, etc.). The access and ability to take advantage of new technologies depends on community's characteristics. Regional irrigator's association's technicians and farmers have been taking advantage of exiting opportunities.	Technologically the sector is not well developed in the region under study and opportunities of access to new emerging technologies have not been good. BINGO evapotranspiration/hydrological research may bring new opportunities to the sector.
LEGAL	Economic and financial regime WFD)	Partially implemented: - Water uses pricing (abstraction or polluter-pays principle) are in place with low taxes for agriculture; - Recovery of the costs of water services is not being practiced.	
	Environmental regulation and legislation (EU and national)	Legal binding requirements exist, although not all totally fulfilled (due to the lack of fiscalization): EU Directives (and their transposition into the national law), such as the Water Framework Directive, the nitrates (Directive 91/676/CEE and later updates), fertilizers (Regulation (EC) No. 2003/2003 of EP); Pesticides **(**Directive 2009/128/ EC**);** Biodiversity (Nature 2000), Birds conservation (79/409/CEE) and Habitats (92/43/CEE); sewage sludge used in agriculture (Directive 86/278/CEE).	
ENVIRON-- MENTAL	Climate	Low Precipitation and storm surges events	Low Precipitation events affecting agriculture
	Water quality	Salt water intrusion; macrophytes blooms; Nitrates (vulnerable zones exist restrictions to nitrogen fertilization).	Nitrates

INTERNAL CONTEXT		
	PT	**CY**
	Big Irrigators associations, with farmers benefiting from public irrigation infrastructures (government funded) for several decades now, that favoured competiveness before and after EU adhesion. Many farmers have presently state of the art irrigation technologies and practices. Agricultural land is very fertile in the region. High level of academic education of irrigator's association's technicians and farmers in the region facilitates access to emerging technologies. Presently, good adaptation capacity to changes (after small and older farmers stopped activity).	Irrigation associations are small entities of 10 or more famers and are not eligible for funding through EU structural/cohesion funds. Each irrigation association is managing its own accounts by receiving water bills from irrigation users. Ageing farm population and low level of trained farmers. Irrigation association managers are farmers and there is lack of technological knowledge. Farmers often seek for advice from extension services (Department of Agriculture).. Lack of training and providers of modern irrigation scheduling technologies (e.g., wireless sensor networks, apps).

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ANNEXES

ANNEX I – BINGO RISK GLOSSARY: TERMS AND DEFINITIONS

NOTE:

1 - The basis of this GLOSSARY is ISO Guide 73:2009.

2 – Some terms and definitions were added. So far (24-sep-2015) their origin is the PREPARED Project.

3 – The column CLARIFICATION intends to develop further clarification to the definitions, in case doubts arise.

The International Standard (ISO 31000:2009) can be applied to any type of risk, whatever its nature, whether having positive or negative consequences. This International Standard (ISO 31000:2009) can be applied throughout the life of an organization, and to a wide range of activities, including strategies and decisions, operations, processes, functions, projects, products, services and assets.

SOURCE: ISO Guide 73:2009, defin. nº	Terms	Definitions	CLARIFICATION AND OTHER SOURCES
		1. RISK	
1.1	RISK	Effect of uncertainty on objectives. NOTE 1 An effect is a deviation from the expected — positive and/or negative. NOTE 2 Objectives can have different aspects (such as financial, health and safety, and environmental goals) and can apply at different levels (such as strategic, organization-wide, project, product and process). NOTE 3 Risk is often characterized by reference to potential events and consequences, or a combination of these. NOTE 4 Risk is often expressed in terms of a combination of the consequences of a hazardous event (including changes in circumstances) and the associated likelihood of occurrence. NOTE 5 Uncertainty is the state, even partial, of deficiency of information related to, understanding or knowledge of an event, its consequence, or likelihood.	Risk is expressed in terms of combination of the consequences (damage) of a hazardous event (including changes in circumstances), and the associated likelihood of occurrence (probability). The level and magnitude of the consequences will depend on the characteristics of the hazardous event as well on the vulnerability of the system. Risk is also often defined as the product of the physical hazard (and its characteristics), the elements at risk and their vulnerability (Blaikie et al., 1994; Nott, 2006).
		2. RISK MANAGEMENT	
2.1	RISK MANAGEMENT	Coordinated activities to direct and control an organization with regard to **risk.**	
2.1.1	Risk management framework	Set of components that provide the foundations and organizational arrangements for designing, implementing, monitoring, reviewing and continually improving **risk management** throughout the organization. NOTE 1 The foundations include the policy, objectives, mandate and commitment to manage risk NOTE 2 The organizational arrangements include plans, relationships, accountabilities, resources, processes and activities. NOTE 3 The risk management framework is embedded within the organization's overall strategic and operational policies and practices.	
2.1.2	Risk management policy	Statement of the overall intentions and direction of an organization related to **risk management.**	

ISO Guide 73:2009, defin. nº	Terms	Definitions	CLARIFICATION AND OTHER SOURCES
2.1.3	Risk management plan	Scheme within the **risk management framework** specifying the approach, the management components and resources to be applied to the **management of risk.** NOTE 1 Management components typically include procedures, practices, assignment of responsibilities, sequence and timing of activities. NOTE 2 The risk management plan can be applied to a particular product, process and project, and part or whole of the organization	
		3. RISK MANAGEMENT PROCESS	
3.1	**RISK MANAGEMENT PROCESS**	**Systematic application of management policies, procedures and practices to the activities of communicating, consulting, establishing the context, and identifying, analysing, evaluating, treating, monitoring and reviewing risk.**	
	Scope		Primary aim. (PREPARED Project) Example: Protection of public health or public safety; Protection of environment; of economic activities
3.2		**Communication and consultation**	
3.2.1	Communication and consultation	Continual and iterative processes that an organization conducts to provide, share or obtain information and to engage in dialogue with **stakeholders** regarding the management of **risk**. NOTE 1 The information can relate to the existence, nature, form, likelihood, significance, evaluation, acceptability and treatment of the management of risk. NOTE 2 Consultation is a two-way process of informed communication between an organization and its stakeholders on an issue prior to making a decision or determining a direction on that issue. Consultation is: - a process which impacts on a decision through influence rather than power; and - an input to decision making, not joint decision making.	
3.2.1.1	Stakeholder	Person or organization that can affect, be affected by, or perceive themselves to be affected by a decision or activity. NOTE A decision maker can be a stakeholder.	
3.2.1.2	Risk perception	View of stakeholder's on a risk, reflecting the needs, issues, knowledge, belief and values.	

ISO Guide 73:2009, defin. nº	Terms	Definitions	CLARIFICATION AND OTHER SOURCES
3.3		**CONTEXT:**	
3.3.1	ESTABLISHING THE CONTEXT	Defining the external and internal parameters to be taken into account when managing risk, and setting the scope and **risk criteria** for the **risk management policy**.	
3.3.1.1	External context	External environment in which the organization seeks to achieve its objectives. Can include: the cultural, social, political, legal, regulatory, financial, technological, economic, natural and competitive environment, whether international, national, regional or local; key drivers and trends having impact on the objectives of the organization; and relationships with, and perceptions and values of external **stakeholders.**	
3.3.1.2	Internal context	Internal environment in which the organization seeks to achieve its objectives. Include, but is not limited to: governance, organizational structure, roles and accountabilities; policies, objectives, and the strategies that are in place to achieve them; the capabilities, understood in terms of resources and knowledge (e.g. capital, time, people, processes, systems and technologies); information systems, information flows and decision-making processes (both formal and informal); relationships with, and perceptions and values of, internal stakeholders; the organization's culture; standards, guidelines and models adopted by the organization; and form and extent of contractual relationships.	
3.3.1.3	Risk criteria	Terms of reference against which the significance of a **risk** is evaluated. NOTE 1 Risk criteria are based on organizational objectives, and **external** and **internal** context. NOTE 2 Risk criteria can be derived from standards, laws, policies and other requirements.	

ISO Guide 73:2009, defin. nº	Terms	Definitions	CLARIFICATION AND OTHER SOURCES
3.4		**RISK ASSESSMENT**	
3.4.1	RISK ASSESSMENT	Overall process of risk identification, risk analysis and risk evaluation.	
3.5		**RISK IDENTIFICATION**	
3.5.1	RISK IDENTIFICATION	Process of finding, recognizing and describing **risks.** NOTE 1 Risk identification involves the identification of risk **sources, events**, their causes and their potential consequences. NOTE 2 Risk identification can involve historical data, theoretical analysis, informed and expert opinions, and stakeholder's needs.	
3.5.1.2	Risk source	Element which alone or in combination has the intrinsic potential to give rise to **risk.** NOTE A risk source can be tangible or intangible	Risk source is where the hazardous event potentially begins. (PREPARED Project (Almeida *et al*., 2011a)
3.5.1.3	Event	Occurrence or change of a particular set of circumstances NOTE 1 An event can be one or more occurrences, and can have several causes. NOTE 2 An event can consist of something not happening. NOTE 3 An event can sometimes be referred to as an "incident" or "accident". NOTE 4 An event without consequences can also be referred to as a "near miss", "incident", "near hit" or "close call".	
3.5.1.4	Hazard	Source of potential harm. A hazard can be a risk source.	A dangerous phenomenon (substance, human activity or condition) that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (MRC-CCAI, 2013). In the context of the BINGO risk assessment, the focus is on hydrological hazards, i.e. floods and droughts (sometimes, "climate change" is also described as a "hazard"; in the common understanding developed here, however, CC is regarded as a factor, a driver, exaggerating the effects of future hazards).

ISO Guide 73:2009, defin. nº	Terms	Definitions	CLARIFICATION AND OTHER SOURCES
	Hazardous event		An event which can cause harm, e.g. a situation that leads to the presence or release of a hazard (Beuken, 2008). The hazardous event is part of the event pathway (PREPARED Project (Almeida *et al.* , 2011a & 2013)
3.5.1.5	Risk owner	Person or entity with the accountability and authority to manage a **risk.**	
3.6		**RISK ANALYSIS**	
3.6.1	RISK ANALYSIS	Process to comprehend the nature of **risk** and to determine the **level of risk.** NOTE 1 Risk analysis provides the basis for risk evaluation (2.24) and decisions about risk treatment. NOTE 2 Risk analysis includes risk estimation.	
3.6.1.1	Likelihood	Chance of something happening. NOTE 1 In risk management terminology, the word “likelihood” is used to refer to the chance of something happening, whether defined, measured or determined objectively or subjectively, qualitatively or quantitatively, and described using general terms or mathematically (such as a probability or a frequency over a given time period). NOTE 2 The English term “likelihood” does not have a direct equivalent in some languages; instead, the equivalent of the term “probability” is often used. However, in English, “probability” is often narrowly interpreted as a mathematical term. Therefore, in risk management terminology, “likelihood” is used with the intent that it should have the same broad interpretation as the term “probability” has in many languages other than English.	Chance of something happening, whether defined, measured or determined objectively or subjectively, qualitatively or quantitatively, and described using general terms or mathematically such as a **probability** or a **frequency** over a given time period. Probability is the measure of the chance of occurrence expressed as a number between 0 and 1, where 0 is impossibility and 1 is absolute certainty. In some languages **probability** is used with the same broad meaning. (PREPARED Project Almeida *et al.*, 2013))
3.6.1.2	Exposure	Extent to which a system is subject to an **event** (ISO GUIDE 73/2009).	Refers to the inventory (and values) of elements that are present in areas in which hazardous events (floods or other) may occur and can be adversely affected (potentially damaged or disrupted) by those events. These values depend on the presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social, cultural assets in places that could be adversely affected (IPCC, 2013)

ISO Guide 73:2009, defin. nº	Terms	Definitions	CLARIFICATION AND OTHER SOURCES
3.6.1.3	Consequence	Outcome of an **event** affecting objectives. NOTE 1 An event can lead to a range of consequences. NOTE 2 A consequence can be certain or uncertain and can have positive or negative effects on objectives. NOTE 3 Consequences can be expressed qualitatively or quantitatively. NOTE 4 Initial consequences can escalate through knock-on effects.	Considered as the extent of harm, which can be expected under certain conditions of exposure, susceptibilities and resilience. The indicators for this component can be separated in two categories; the first one gives details on the general characteristics of the hazardous event and the second one covers the vulnerability of the different elements at risk.
3.6.1.4	Probability	Measure of the chance of occurrence expressed as a number between 0 and 1, where 0 is impossibility and 1 is absolute certainty. NOTE See definition 3.6.1.1, Note 2.	
3.6.1.5	Frequency	Number of **events** or outcomes per defined unit of time. NOTE Frequency can be applied to past events or to potential future events, where it can be used as a measure of likelihood / probability.	
3.6.1.6	Vulnerability	Intrinsic properties of something resulting in susceptibility to a risk source that can lead to an event with a consequence.	Vulnerability refers to the propensity or capacities of exposed elements (such as human beings, their livelihoods, and assets) that favour, either adversely or beneficially, the adverse effects of hazardous events. NOTE: Within BINGO vulnerability consists on exposure, susceptibility (or sensitivity) and resilience.
	Susceptibility		Susceptibility (within BINGO susceptibility and sensitivity, will act as synonyms) is the degree to which the system is affected, depending on the own intrinsic characteristics of its exposed elements within the area in which hazardous events may occur. These intrinsic properties include, for instance, the physical characteristics of exposed elements (infrastructures, buildings, etc.), the economic and social context of the community, etc. For floods, for instance, important capacities are the awareness and preparedness of affected people and the existence of mitigation measures to reduce the effects of the hazards, like warning systems and emergency plans.

ISO Guide 73:2009, defin. nº	Terms	Definitions	CLARIFICATION AND OTHER SOURCES
3.6.1.7	Risk matrix	Tool for ranking and displaying **risks** by defining ranges for **consequence** and **likelihood**	
3.6.1.8	Level of risk	Magnitude of a **risk** or combination of risks, expressed in terms of the combination of **consequences** and their **likelihood.**	
	Risk factor		Something that can have an effect on the risk level, by changing the probability or the consequences of an event. Risk factors are often causes or causal factors that can be acted upon using risk reduction measures. Typically three main categories are considered namely human factors, environmental factors and equipment/infrastructure factors. (PREPARED Project – Almeida *et al.*, 2011a &2013)
3.7		**RISK EVALUATION**	
3.7.1	RISK EVALUATION	Process of comparing the results of **risk analysis** with **risk criteria** to determine whether the **risk** and/or its magnitude is acceptable or tolerable. NOTE Risk evaluation assists in the decision about risk treatment.	
3.7.1.1	Risk attitude	Organization's approach to assess and eventually pursue, retain, take or turn away from risk.	
3.7.1.2	Risk appetite	Amount and type of **risk** (that an organization is willing to pursue or retain.	
3.7.1.3	Risk tolerance	Organization's or **stakeholder**'s readiness to bear the **risk** after **risk treatment** in order to achieve its objectives. NOTE Risk tolerance can be influenced by legal or regulatory requirements.	
3.7.1.4	Risk aversion	Attitude to turn away from **risk.**	
3.7.1.5	Risk aggregation	Combination of a number of risks into one **risk** to develop a more complete understanding of the overall risk.	
3.7.1.6	Risk acceptance	Informed decision to take a particular **risk.** NOTE 1 Risk acceptance can occur without **risk treatment** or during the process of risk treatment. NOTE 2 Accepted risks are subject to **monitoring a**nd **review.**	

ISO Guide 73:2009, defin. nº	Terms	Definitions	CLARIFICATION AND OTHER SOURCES
3.8		**RISK TREATMENT**	
3.8.1	RISK TREATMENT	Process to modify **risk**.	NOTE 1 Risk treatment can involve: avoiding the risk by deciding not to start or continue with the activity that gives rise to the risk; taking or increasing risk in order to pursue an opportunity; removing the risk source; changing the likelihood; changing the consequences; sharing the risk with another party or parties (including contracts and risk financing); and retaining the risk by informed decision. NOTE 2 Risk treatments that deal with negative consequences are sometimes referred to as “risk mitigation”, “risk elimination”, “risk prevention” and “risk reduction”. NOTE 3 Risk treatment can create new risks or modify existing risks.
	Risk reduction measure		Set of actions allowing modification of risk. Risk Reduction Measures (RRM) includes any process, policy, device, practice, or other actions which modify risk and may not always exert the intended or assumed modifying effect. (PREPARED project- Almeida *et al.*, 2011b)
	Risk reduction action		Specific action needed to properly implement the selected Risk Reduction Measures (RRM). Actions can be of very different nature. (PREPARED project- Almeida *et al.*, 2011b)

ISO Guide 73:2009, defin. nº	Terms	Definitions	CLARIFICATION AND OTHER SOURCES
3.8.1.1	Control	Measure that is modifying **risk.** NOTE 1 Controls include any process, policy, device, practice, or other actions which modify risk. NOTE 2 Controls may not always exert the intended or assumed modifying effect.	
3.8.1.2	Risk avoidance	Informed decision not to be involved in, or to withdraw from, an activity in order not to be exposed to a particular **risk.** NOTE Risk avoidance can be based on the result of **risk evaluation** and/or legal and regulatory obligations.	
3.8.1.3	Risk sharing	Form of **risk treatment** involving the agreed distribution of **risk** with other parties. NOTE 1 Legal or regulatory requirements can limit, prohibit or mandate risk sharing. NOTE 2 Risk sharing can be carried out through insurance or other forms of contract. NOTE 3 The extent to which risk is distributed can depend on the reliability and clarity of the sharing arrangements. NOTE 4 Risk transfer is a form of risk sharing.	
3.8.1.4	Risk financing	Form of risk treatment involving contingent arrangements for the provision of funds to meet or modify the financial consequences should they occur.	
3.8.1.5	Risk retention	Acceptance of the potential benefit of gain, or burden of loss, from a particular **risk** NOTE 1 Risk retention includes the acceptance of **residual risks.** NOTE 2 The **level of risk** retained can depend on **risk criteria.**	
3.8.1.6	Residual risk	Risk remaining after risk treatment. NOTE 1 Residual risk can contain unidentified risk. NOTE 2 Residual risk can also be known as “retained risk”.	

ISO Guide 73:2009, defin. nº	Terms	Definitions	CLARIFICATION AND OTHER SOURCES
3.8.1.7	Resilience	Adaptive capacity of an organization in a complex and changing environment.	Adaptive capacity of a system to endure any perturbation, like floods, droughts or other hazardous event, maintaining significant levels of efficiency in its social, economic, environmental and physical components. NOTE Resilience to a hazardous event damages can be considered only in places with past events, since the main focus is on the experiences encountered during and after the events
3.8.2.1	Monitoring	Continual checking, supervising, critically observing or determining the status in order to identify change from the performance level required or expected. NOTE Monitoring can be applied to a risk management framework, risk management process, risk or control.	
3.8.2.2	Review	Activity undertaken to determine the suitability, adequacy and effectiveness of the subject matter to achieve established objectives. NOTE Review can be applied to a risk management framework, risk management process, risk or control.	
3.8.2.3	Risk reporting	Form of communication intended to inform particular internal or external **stakeholders** by providing information regarding the current state of **risk** and its management.	
3.8.2.4	Risk register	Record of information about identified **risks.** NOTE The term “risk log” is sometimes used instead of “risk register”.	
3.8.2.5	Risk profile	Description of any set of **risks.** NOTE The set of risks can contain those that relate to the whole organization, part of the organization, or as otherwise defined.	
3.8.2.6	Risk management audit	Systematic, independent and documented process for obtaining evidence and evaluating it objectively in order to determine the extent to which the **risk management framework**, or any selected part of it, is adequate and effective.	

ANNEX II – TIPS TO PERFORM THE NEXT STEPS OF WP4

Risk identification (WP4.2)

Risk is associated with the interaction between environmental phenomena, communities and the surrounding environment. Risk is expressed in terms of a combination of the consequences of an event or a change in circumstances, and the associated likelihood of occurrence. Thus, to identify risks, it is necessary to take into account the *nature of the hazard* and the *factors that affect the consequences* (impacts). The consequences depend on the degree of exposure (measured by the number of the elements at risk or by their value), on their vulnerability (measured by the susceptibility of those elements at risk suffering damages as a consequence of certain level of hazard) and on their resilience (coping and recovery capacity).

The aim of *risk identification* in work package 4.2 is to identify possible risks that may affect, either negatively or positively, the objectives of the activity under analysis (eg. water resources management, public water supply, etc.). Answering the following questions identifies the risk: *What can happen? How can it happen? Why could it happen?*

Risk identification (ISO 73:2009) is the process consisting of identification of risk sources, events, their causes (or sets of circumstances) and their potential consequences. Involves:

1. Identify relevant hazards, risk sources and risk factors:
    - Relevant **hazards** identification (causes or sets of circumstances of the events).

      Examples of water related potentially hazardous natural phenomena are:
        - Atmospheric: tropical storms;
        - Hydrologic: coastal flooding; desertification; salinization; drought; erosion and sedimentation; river flooding; storm surges;
    - **Risk sources (causes)** identification (sources can be external, internal or a conjugation of both). Sources can include hazards and elements exposed (Opportunities, threats and the hazards are the causes or sources of risk). Sources refer to element which alone or in combination has the intrinsic potential to give rise to risk. Is where the hazardous event potentially begins. Can be tangible or intangible;
    - **Risk factors** Identification (something that can have an effect on the risk level, meaning that can affect consequences or likelihood).

Examples: infrastructures conditions; human physical vulnerabilities; social and economic vulnerabilities, etc..

2. Explore scenarios and potential **events** (occurrence or change of a particular set of circumstances - Table 1.1);
3. Assess the potential effect of climate change trends (areas of impact).

Cause (Risk Source) >> Fact (Event) >> Effect (Impact or Consequence)

There are two main ways to identify risk:

1. Identifying retrospective risks:

   Retrospective risks are those that have previously occurred, such as incidents or accidents[10]. Retrospective risk identification is the most common and the easiest way to identify risk. It is easier to believe something if it has happened before and it is easier to quantify its impact and to see the damage it has caused.

2. Identifying prospective risks:

   - Prospective risks are often harder to identify. These are things that have not yet happened, but might happen sometime in the future.
   - Identification should include all risks, whether or not they are currently being managed. The rationale here is to record all significant risks and monitor or review the effectiveness of their control.

As *tips for effective risk identification* are referred the following:

- Select a risk identification methodology appropriate to the type of risk and the nature of the activity;
- Assure that risk identification methodology is compatible with risk analysis and risk evaluation to be performed (see next point).
- Involve the right people in risk identification activities;

[10] An event can sometimes be referred to as an “incident” or “accident”.

An event without consequences can also be referred to as a “near miss”, “incident”, “near hit” or “close call”.

An **accident** is a bad event caused by error or by chance. Accidents are always unintentional, and they usually result in some damage or injury.

All accidents can also be described as incidents, but not all incidents are accidents. Accident definition is often similar to incident, but supports the mindset that it *could not have been prevented.*

- Take a life cycle approach to risk identification and determine how risks change and evolve throughout this cycle.

Risk analysis and risk evaluation (WP4.3)

Risk analysis

Risk analysis is about comprehending the *nature of risk* and estimating the *level of risk*. It is the process of understanding how risk arises and of determining the consequences (impact or event outcomes such as losses, environmental consequences, etc.) and their probabilities for identified risk events. Risk analysis involves combining the possible consequences (or impact) of an event, with the likelihood of that event occurring. The result is a 'level of risk'.

Risk analysis starts by identifying existing strategies and controls that act to minimize negative risk and enhance opportunities that should have been identified in the context. Then **risk analysis** involves consideration of the sources and factors of risk:

- Determining the **consequences** or outcome of an event affecting objectives (may be a negative impact or an opportunity);
- Determining the **likelihood** associated with occurrence of those consequences (chance of an event happening);
- Estimate the **level of risk** (magnitude of a risk or conjugation of risks, expressed in terms of the combination of consequences and their likelihood).

Risk analysis should be concluded only after cconsidering and identifying any uncertainties in the estimates.

As referred in points 2.1 and 2.7 the structure for risk analysis is part of the context, and although probability-impact matrixes seems to be presently the most popular choice among BINGO partners, a final decision was not yet taken by all risk owners.

The definition of the structure for risk analysis involves two sequential steps:

- Isolate the categories of risk to manage. This allows greater depth and accuracy in identifying significant risks - this step was performed under WP 4.1. The scopes established narrowed analysis for certain categories of risk in each case study and specific objectives formulated the problems under analysis in a "mensurable" way;
- The choice of tools to develop risk analysis will depend upon the type of activity or issue, its complexity and the context of the risks - the activities/ issues and

the RMP context were established in WP 4.1. The tools to perform risk analysis in WP 4.3, in order to estimate the level of risk, should be selected simultaneously with risk identification tools, in WP 4.2, in order to assure compatibility and, therefore, the success of risk assessment.

Three categories or ***types of risk analysis*** can be used to determine level of risk: qualitative; quantitative and semi-quantitative. They differ significantly in the level of information required and level of accuracy achieved.

In *qualitative* analysis, the magnitude and likelihood of potential consequences are presented and described in detail. The scales used can be formed or adjusted to suit the circumstances, and different descriptions may be used for different risks. This process prioritizes risks according to their potential impact on project objectives.

- *Qualitative* assessment defines consequence, probability and level of risk by significance levels such as “high”, “medium” and “low”, may combine consequence and probability, and evaluates the resultant level of risk against qualitative criteria. The scales used can be formed or adjusted to suit the circumstances, and different descriptions may be used for different risks. This process prioritizes risks according to their potential impact on project objectives. Figure II. 1 illustrates qualitative assessment;

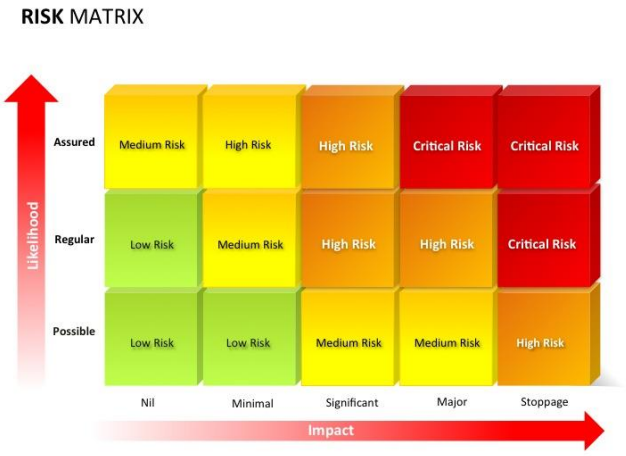

Figure II. 1– Example of qualitative risk matrix

- *Quantitative analysis* is the process of analysing numerically the probability of each risk event and its impact on the project objectives. It estimates practical values for consequences and their probabilities, and produces values of the level of risk in specific units defined when developing the context. Full quantitative analysis may not always be possible or desirable due to insufficient

information about the system or activity being analysed, lack of data, influence of human factors, etc. or because the effort of quantitative analysis is not warranted or required. In such circumstances, a comparative semi-quantitative or qualitative ranking of risks by specialists, knowledgeable in their respective field, may still be effective;

- *Semi-quantitative* methods are a mix of both. It uses use numerical rating scales for consequence and probability and combine them to produce a level of risk using a formula. Scales may be linear or logarithmic, or have some other relationship; formulae used can also vary. Figure II. 2 illustrates this case.

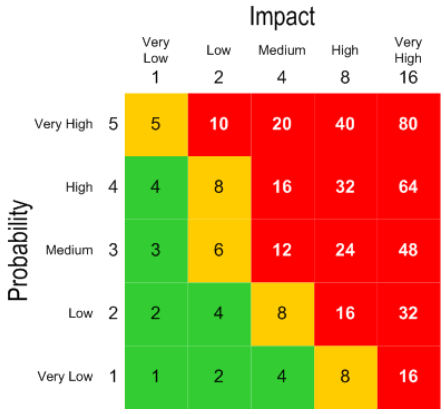

Figure II. 2 – Example of semi-quantitative risk matrix

The existing risk analysis methods are listed in Annex II. The most common tolls are listed in Figure II. 3.

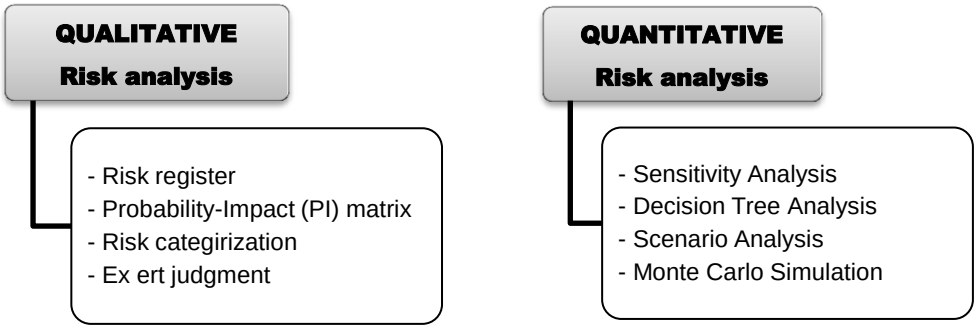

Figure II. 3: Most common risk analysis methods

Tips for effective risk analysis

- Risk analysis is usually done in the context of existing controls – take the time to identify them

- The risk analysis methodology selected should be comparable to the significance and complexity of the risk being analysed (risk criteria), i.e. the higher the potential consequence the more rigorous the methodology
- Risk analysis tools are designed to help rank or priorities risks. To do this they must be designed for the specific context and the risk dimension under analysis.

Risk analysis provides the basis for risk evaluation and decisions about risk treatment.

Risk evaluation

Risk evaluation is the process of comparing the results of risk analysis with risk criteria to determine whether the risk and/or its magnitude is acceptable or tolerable. The result of a risk evaluation is a prioritized list of risks that require further action. This step is about deciding whether risks are acceptable or need treatment.

Risk evaluation assists in the decision about risk treatment. It involves:

- **Evaluate the risk** (levels of risk found in risk analysis are compared with risk criteria established when the context was defined);
- **Compare and reassess estimated risk** (when acceptance criteria are not met those risks needing actions are prioritised to be selected in risk treatment).

As referred in point 2.7, in WP 4.1 the risk criteria was not fully established and only the parameters to be taken in account were identified, due to the time required to discuss the tolerance levels with the stakeholders whose objectives need to be taken in account. It needs to be established in WP 4.3.

When defining risk criteria, factors to be considered should include the following (ISO Guide 73:2009, definition 3.3.1.3):

- structure of the risk analysis:
    - the nature and types of causes and consequences that can occur and how they will be measured;
    - how likelihood will be defined;
    - the timeframe(s) of the likelihood and/or consequence(s);
    - how the level of risk is to be determined;
- the views of the stakeholders;
- the level at which risk becomes acceptable or tolerable; and
- whether combinations of multiple risks should be taken into account and, if so, how and which combinations should be considered.

Tips for defining risk criteria

Risk criteria establish measures of risk significance; tolerance levels and views of stakeholders.

- Decide or define the acceptable level of risk for each activity;
- Determine what is unacceptable;
- Clearly identify who is responsible for accepting risk and at what level.

The importance of correctly choose an adequate structure for all steps of risk assessment is put in evidence in the Guidance developed for WP 4.1 implementation (Rocha, 2016). Ultimately, if no satisfactory risk assessment is achieved (Figure II. 4) reformulation of all the steps may be necessary. Figure II. 5 helps to identify which steps may need reformulation.

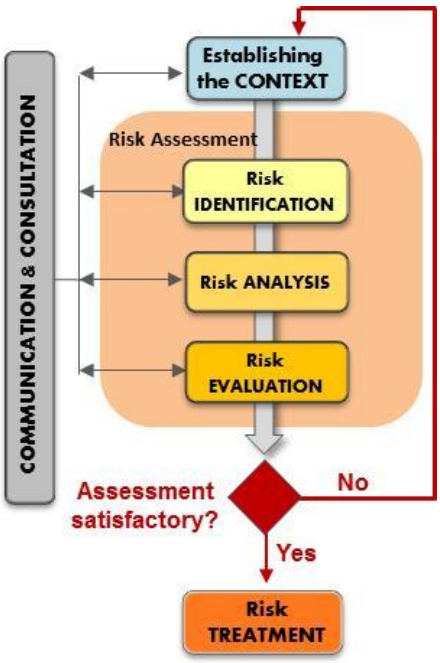

Figure II. 4 – Reformulation of context in case of unsatisfactory risk assessment

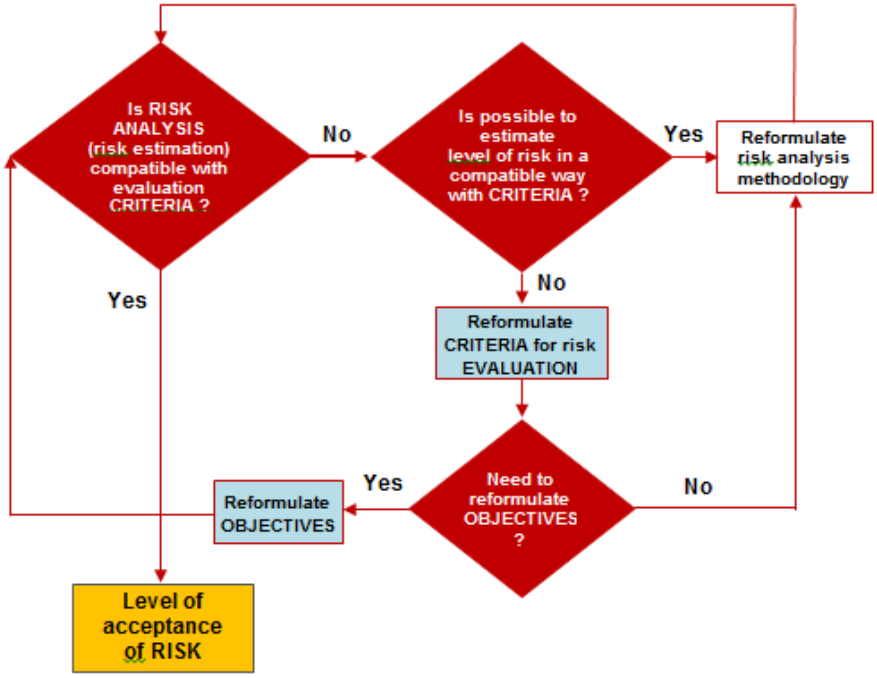

Figure II. 5 – Steps to perform in case risk assessment cannot be achieved (Rocha, 2016)

Risk acceptance

A risk may be accepted for the following reasons (Kanona, 2007):

- The cost of treatment far exceeds the benefit, so that acceptance is the only option (applies particularly to lower ranked risks);
- The level of the risk is so low that specific treatment is not appropriate with available resources;
- The opportunities presented outweigh the threats to such a degree that the risks justified;
- The risk is such that there is no treatment available, for example the risk that the business may suffer storm damage.